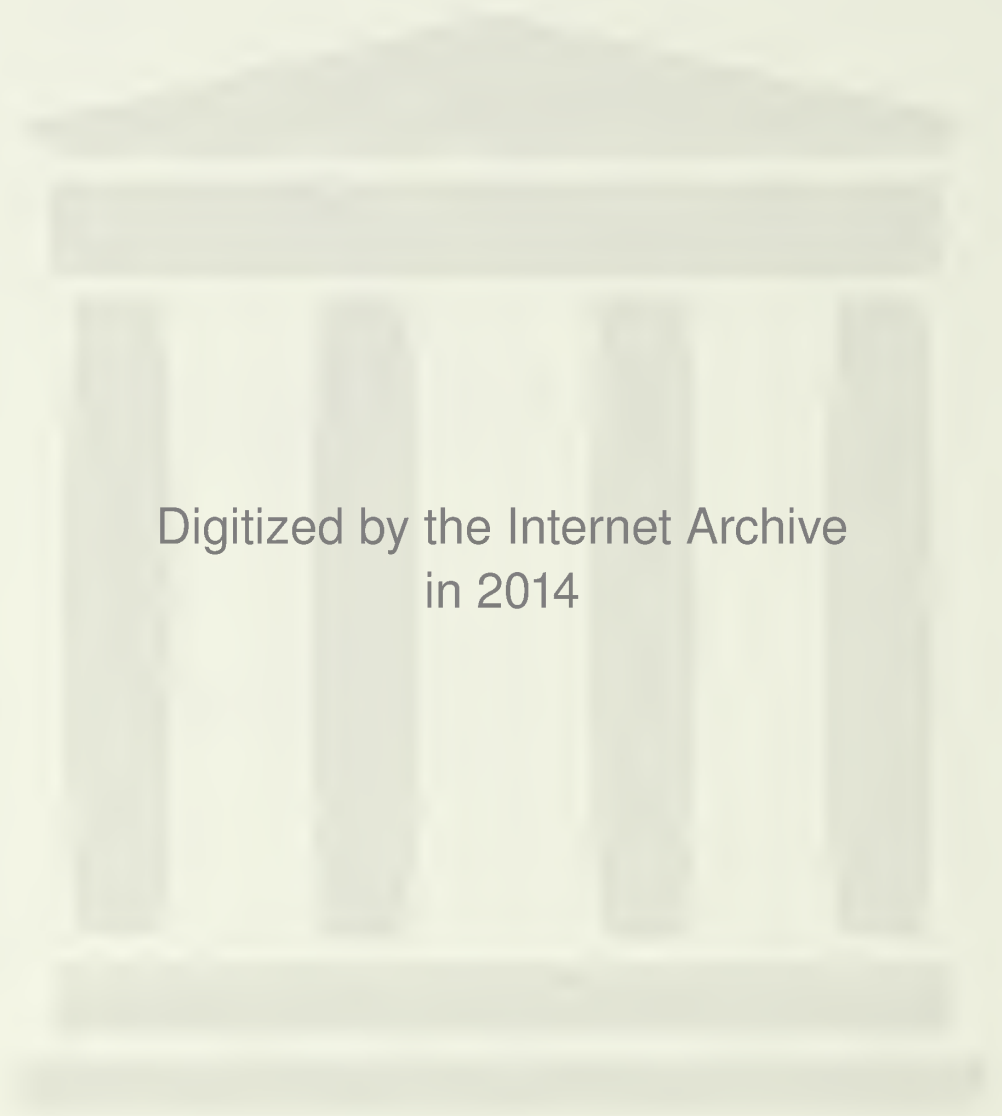
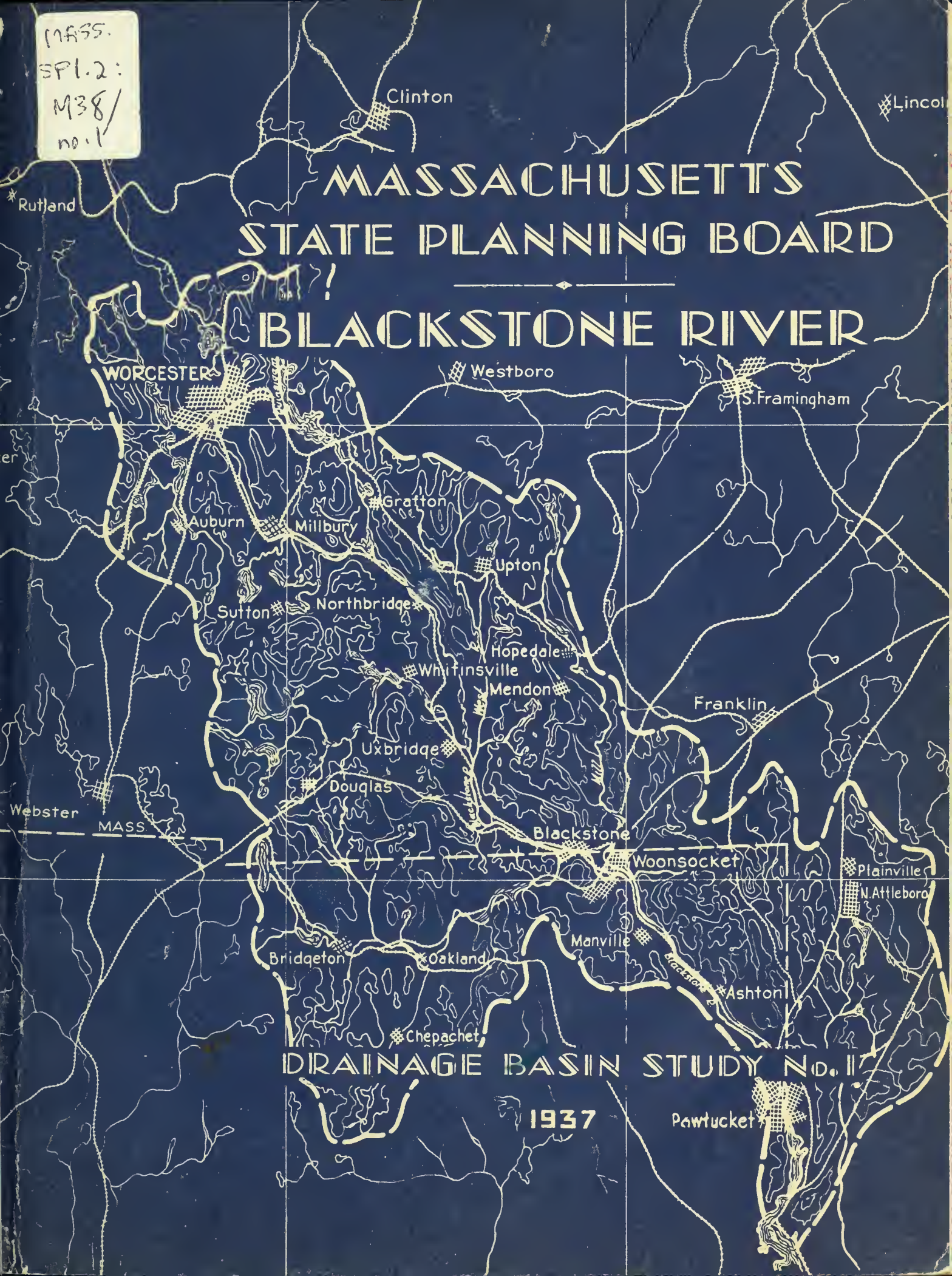


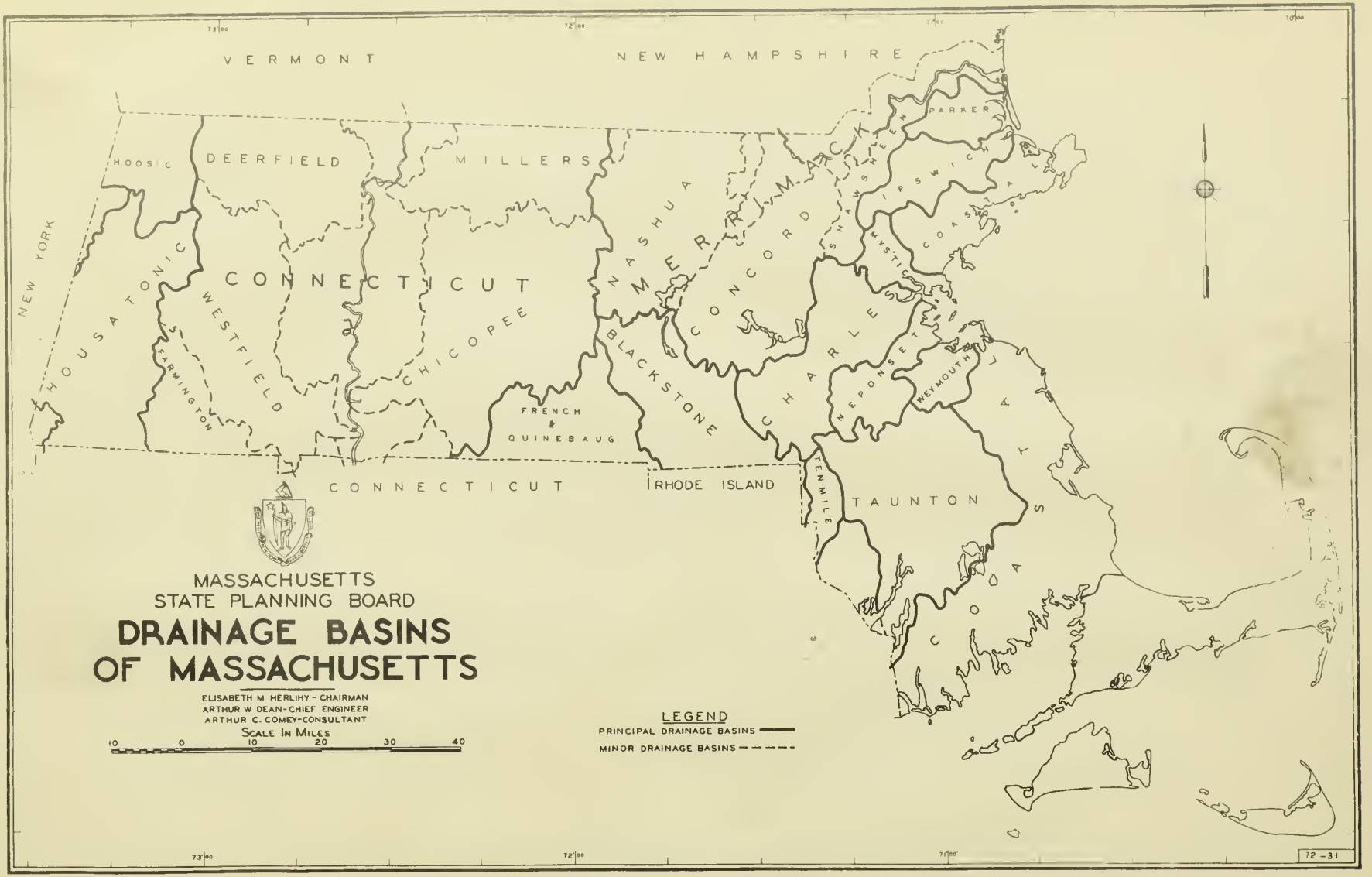
# MASSACHUSETTS
# STATE PLANNING BOARD

# BLACKSTONE RIVER




## DRAINAGE BASIN STUDY No. II

1937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FRENCH & QUINEBAUG
NASHUA
MERRIMACK
CONCORD
SHAWSHEEN
PARKER
IPSWICH
MYSTIC
COASTAL
BLACKSTONE
CHARLES
NEPONSET
WEYMOUTH
TAUNTON
TENMILE
MASSACHUSETTS
STATE PLANNING BOARD
DRAINAGE BASINS
OF MASSACHUSETTS
ELISABETH M HERLIHY - CHAIRMAN
ARTHUR W DEAN - CHIEF ENGINEER
ARTHUR C. COMEY - CONSULTANT
SCALE IN MILES
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LEGEND
PRINCIPAL DRAINAGE BASINS
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MASSACHUSETTS DRAINAGE BASIN STUDIES

# INTRODUCTION TO DRAINAGE BASIN STUDIES

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# DRAINAGE BASIN STUDY NO.1 - BLACKSTONE RIVER

FROM FIELD SURVEYS AND DATA
Gathered by
THE WORKS PROGRESS ADMINISTRATION PROJECTS
Sponsored by
STATE PLANNING BOARD
and
STATE DEPARTMENT OF PUBLIC HEALTH

1937


Prepared by
THE MASSACHUSETTS STATE PLANNING BOARD
ELISABETH M. HERLIHY, CHAIRMAN

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COMMISSIONER OF CONSERVATION
COMMISSIONER OF PUBLIC HEALTH
COMMISSIONER OF PUBLIC WORKS

ARTHUR W. DEAN, CHIEF ENGINEER
ARTHUR C. COMEY, CONSULTANT

# F O R E W O R D

The Massachusetts State Planning Board has received from Arthur W. Dean, Chief Engineer, and Arthur C. Comey, Consultant, addressed to the Board and the National Resources Committee, the following Staff Report dealing particularly with the Blackstone River Basin as the first of a series of Massachusetts Drainage Basin Studies.

The discussion of the precise subject matter of this first volume; i.e., the Blackstone River Basin, is preceded by an introductory statement of the conditions and needs in the State as a whole. Of particular interest is the assurance that after all of the basin studies are completed, a concluding summary will be submitted on problems and proposals for their solution.

The Board is in cordial agreement with its Chief Engineer and its Consultant that the water resources of a region constitute one of the most vital elements of its wealth. It is the foundation of the industrial life of the community and at the same time it exerts a wide and powerful influence over health, recreation, land use and navigation.

Under proper legislation and control water resources mean the encouragement of industry with resultant opportunities for employment, pure drinking water in the homes, the promotion of agriculture, the protection of wildlife, the enlargement of recreational opportunities, and the enhancement of navigation. On the other hand, without such regulation and control the water resources of a community may mean the decrease of industrial opportunities, disease through pollution, suffering and hardship through an insufficient supply, danger to life and property during flood seasons, injury to agricultural areas through soil erosion,destruction of fish and game life, elimination of winter sports, and the curtailment of navigation.

The Board is happy to accept this initial report, therefore,as the first step in a study which it hopes to see continued throughout the entire State. It is only through the compilation of data based upon actual surveys that an approach to a comprehensive solution may be hoped for. The Board, accordingly, unanimously adopted the following vote at a meeting on Wednesday, January 5, 1938.

VOTED: That the Massachusetts State Planning Board accepts and orders released for public distribution the Staff Report on Massachusetts Drainage Basin Studies; Introduction; Drainage Basin Study No. 1, Blackstone River, received from Arthur W. Dean, Chief Engineer and Arthur C. Comey, Consultant.

In accepting the report the Board desires at the same time to record its appreciation of the invaluable assistance rendered by others in the compilation of the material. This is particularly true in the case of the Massachusetts Department of Public Health. It has not only cooperated through the sponsorship and direction of relief projects, but also through personal assistance and advice and access to the practically unlimited information contained in its files.

The Board also recognizes its indebtedness to the staff employed on the W.P.A. State Planning Projects. While the present situation may be looked upon as a temporary means of relieving unemployment, it should be noted that in the preparation of this and similar material the W.P.A. staff has participated in a work of permanent value to the State.

To the Water Technician, Theodore Human, Jr., to its Chief Engineer, Arthur W. Dean, and to the other members of its own permanent staff the Board is always grateful. In this report, as in all other tasks assigned to them, the staff has been loyal, efficient and persevering. They are to be congratulated upon rendering a service of which they have every reason to feel distinctly proud.

And finally, the Board is deeply appreciative of the assistance rendered by the National Resources Committee particularly through its Consultant, by the New England Regional Planning Commission, and by numerous other agencies, public and private. Through their cooperation the Board is able to present to the Commonwealth of Massachusetts, herewith, the first of a series of reports which should prove of enduring value and benefit.

MASSACHUSETTS STATE PLANNING BOARD

Elisabeth M. Herlihy

CHAIRMAN

# LETTER OF TRANSMITTAL

November 30, 1937

To the Massachusetts State Planning Board
and the National Resources Committee

Gentlemen:

We submit herewith a staff report constituting the first volume of Massachusetts Drainage Basin Studies. Included herein is an introductory statement of the conditions and needs in the state as a whole, followed by the first of the studies dealing with individual basins, -- Drainage Basin Study No. 1 - The Blackstone River. After all of the basin studies are completed it is intended to issue a concluding summary on Problems and Proposals for Solution Confronting the State.

The Blackstone River Basin study is largely based on field surveys and data gathered by the Works Progress Administration State Planning Projects, sponsored and directed by the Massachusetts State Planning Board and by the State Department of Public Health. Basic use has also been made of the U.S. Engineer's so-called 308 reports, the U.S. Geological Survey records and other public documents. Maps, charts and graphs have been drawn or compiled by technicians furnished by the Works Progress Administration.

Staff curtailments and rigid Federal restrictions have delayed publication, but it should be gratifying to the Massachusetts State Planning Board that during the progress of these reports we have been able to contribute to Federal departments and local agencies much original data from initial surveys and compilations. This has in many cases already proven ample justification for the State Planning Board's sponsored projects.

This report has been in the immediate charge of Theodore Human, Jr., water technician, whose services were for most of the year supplied by the National Resources Committee. Several members of the State Planning Board's state staff have assisted in co-ordinating and rounding out the work of the W.P.A. staffs.

It is believed that there is being presented for the first time a reasonably complete picture of the water problems of the state, both in their multifarious aspects of supply, flood, power, pollution and the like, and in their relations to other aspects of the state plan, such as recreation, land use and transport.

Respectfully submitted,

Arthur W. Dean
Chief Engineer

Arthur C. Comey
Consultant

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# INTRODUCTION

to

# MASSACHUSETTS DRAINAGE BASIN STUDIES

# I N T R O D U C T I O N

## A. Water Resources Planning

Water resources planning involves the co-ordinated development and control of the many and varied uses of water in harmony with the social and economic needs of the area.

In a bulletin published by the National Resources Committee, under date of May 26, 1936, entitled "The Cost of Ignorance", it is well stated that,

> "Our use and enjoyment of all the natural resources are largely dependent upon the degree to which we can put water to work and keep it from doing harm. This, in turn, depends upon exact knowledge of such factors as rainfall, snowfall, the flow of streams, the level at which water stands in the ground, the rate at which it evaporates or at which it transpires from trees and other vegetation, and the chemicals, suspended matter or impurities which are found in it. Although it has been centuries since water was first used to produce power, thousands of years since it was first employed for irrigation, and perhaps tens of thousands of years since it first aroused the curiosity of human or semi-human creatures, our knowledge of its behavior is still far from complete. In this respect the United States, with peculiar problems of its own, has lagged behind Europe."

Water resources of a region are one of the most vital elements of its wealth, yet in many respects, especially in communities where water is plentiful, these resources have been carelessly wasted or put to uses inconsistent with the best social and economic development of the community.

Water, like fire, is "a good servant but a bad master", and we are confronted by the problem of reducing the destructive effects caused by floods on our important streams, and at the same time give proper attention to the correlated subjects of low water control, water power, water supply, pollution, irrigation, drainage, recreation and navigation.

Planning for the future control of water involves many basic functions in the life of the community. It unavoidably involves planning for land, industry, power, recreation, transport and many other activities of man. Water resources planning must be studied not only from the viewpoint of specific problems within its own immediate technical field, but also in its relations to the problems of physical planning as a whole.

Even when limited to the restricted technical problems of its own field, we are still involved in highly complex considerations in trying to satisfy the various competing uses for water. In the solution of a flood-control problem it may be found desirable to create large storage reservoirs on the upper tributaries of a river to retain flood waters, but it may be impossible to justify their cost on the basis of flood protection alone. If hydro-electric power could be developed at such reservoirs at moderate additional expense and without defeating their main purpose part of the initial expense might be charged against power production. Further, by proper regulation of the flood storage reservoirs it may be possible to increase materially the minimum stream flow,thus alleviating heavy pollution conditions. Such an integrated plan, resulting in a combination of benefits,might be found to have economic validity.

Areas reserved as watersheds for the public supply can and should be studied, in co-operation with the Department of Public Health, to see whether such reserved slopes can be developed for limited recreation purposes, for game propagation and sanctuaries, or as nurseries for tree stock for use in public reforestation.

The public has begun to realize the necessity for conserving our natural wealth, not the least important of which is the conservation of water resources. This cannot be effectively or intelligently done without planning, as defined above. The location of a new industry in a region, the design of a sewage disposal plant, the drainage of a swamp, should only be made after an intelligent consideration of the future development of the region and the demands on its water resources.

In the past several excellent studies have been made of one or another of the various phases of water resources in the Commonwealth. The report of the Commissioner on Waterways and Public Lands on the Water resources of the state in 1918, listed as Senate Document No. 289, was an excellent and exhaustive study of the developed and potential power at that time. Likewise, the House Report of 1922, dealing with the future water supply requirements of the state, together with the many special reports by the State Department of Public Health, have all been excellent studies of some particular phase of water resources, but until now there has never been a state-wide study dealing with all the various phases of water resources and their inter-relationships.

From a brief consideration of these various problems it became evident that such a study should be undertaken, having for its ultimate objective the definition of a general policy of priority of water uses and, based upon this definition, the development of a balanced program for the integrated solution of all the phases of water resources - the study should be continued until a complete plan of water conservation for Massachusetts is achieved.

## B. Problems Confronting the State

The water-resource problems of Massachusetts, which are similar to those common to other highly industrialized regions, may be classified as follows: Flow Control, Water Power, Water Supply, Pollution, Irrigation, and Drainage, Recreation, and Navigation. However, problems vary from basin to basin throughout the state, and each must be treated as an individual case, with the method of analysis and technical solution depending upon the relative importance of the various conditions encountered in the particular river valley. A general discussion of these various problems follows:

### 1. Flow Control

At the present time no flow control exists, either of floods or low water, other than regulation by the owners of privileges on the various streams. When the reservoirs which may be constructed under interstate compacts for the Connecticut and Merrimack Rivers are completed improved control of both high and low flow will be obtained. While primarily designed to control floods, the operation of the proposed reservoirs in the off-flood seasons should considerably increase the present low water flow, in the case of the Merrimack River, by about 50 per cent. The manner of operation will vary from season to season, and will depend upon careful study and consideration of all hydrological factors. These low water control efforts will incidentally afford appreciable benefits to power, sanitation, recreation, water supply and other uses.

Flood control, the necessity of which was emphasized by the tremendous losses of the 1936 flood, has become a problem of paramount importance in many localities. Damages throughout the state have been variously estimated at anywhere from thirty-five to forty million dollars. In general, the approach to this problem divides itself into two parts, - interstate problems and intrastate problems. While the heavy damages on the Connecticut River at Springfield, West Springfield and other places along the river might at first appear to be problems of state importance only, they are really problems of interstate co-operation, since a large proportion of the damage was caused by the tremendous volumes of water carried by the Connecticut River and its tributaries from its sources in New Hampshire and Vermont. Local control of the Massachusetts tributaries of the Connecticut River would be beneficial along the tributaries themselves, but such control cannot, of

course, compensate for or diminish the large volumes of flood water in the main streams as it enters the state.

Flood problems of interstate rivers can only be solved by interstate co-operation. Recognizing this fact, several of the states in New England formed interstate compact commissions, the Massachusetts State Planning Board acting, by the authority of the Legislature, as this commission for Massachusetts. After considerable research and study these state commissions, assisted by the United States Army Engineers, drew up compacts for the carrying out of a program of flood control for the Merrimack and Connecticut Rivers based on an equitable division of responsibility between the states concerned, in accordance with plans and studies conducted by the United States Army Engineers. These plans have now been ratified by the Massachusetts, New Hampshire, Vermont and Connecticut Legislatures. They have not, however, been approved by Congress, pending a decision on proposed Federal legislation which, it is claimed, conflicts with the power clauses in the compacts.

The design of flood-control measures for the protection of highly industrialized regions such as are found in Massachusetts requires a considerable degree of engineering skill and ingenuity and the application of many different forms of flood control. Because of our densely populated valleys and the concentration in municipalities on the streams, preventive measures of flood control are difficult, for it is often impossible to find adequate sites for storage reservoirs without destroying large parts of communities, with consequent high damage costs. In many instances these conditions force the use of palliative measures of control along the stream itself, such as dikes, riprapping and channel improvements. These local improvements, in combination with storage reservoirs, are adequate to eliminate damage from ordinary floods, and are usually designed so as to substantially reduce the highly destructive peak floods and consequent extreme damage.

2. Water Power

The problem of undeveloped hydro-electric power in the state is not of great importance. Early in the history of the Commonwealth most of the larger sites were developed, and with the growth of more and more industries all the economically available water power was utilized.

> "Throughout this state and, in fact, the rest of the country, there has been a marked change in the use of small water powers during the last half century. ***** The entire western hill region was formerly fairly dotted with small grist mills, chair and bedstead factories, woolen mills, etc., but the change to modern conditions, with larger mills and larger power requirements, together with increased transportation facilities,

> and the development of steam and gasoline engines and electric power, have already done away with these small water power privileges, except where they are so located as to possess other advantages."*

The undeveloped hydro-power of the state has been estimated in excess of 100,000 h.p., based upon the flow available 80 per cent of the time. However, preliminary surveys indicate that the development of most of this power cannot be economically justified.

Tables representing power, potential and developed, are apt to be misleading. For instance, much potential water power exists which under ordinary circumstances would be too costly to develop. Furthermore, quoting again from Senate Document No. 289:

> "To avoid confusion in comparing potential horsepower with the horsepower of installed water wheels, it should be kept in mind that the potential power of a stream computed upon a continuous operation of 24 hours a day also represents the total wheel power for the same period of operation. If, however, there is pondage sufficient to store one-half of the flow, then twice the wheel power developed in 24 hours can be operated during 12 hours***** therefore, it is possible, with adequate pondage, for the installed capacity of water wheels to be in excess of the potential power of the stream".

3. Water Supply

Municipal:-The problems of domestic water supply within Massachusetts are well in hand; 243 of the 355 municipalities of the Commonwealth have public water supplies. Some of these, however, are still inadequate as to quantity for either domestic purposes or fire protection. The municipalities without water supply, are, for the most part, sparsely populated. Generally, the sources of supply for the larger municipalities and those of the western part of the state are surface waters. With the notable exception of metropolitan Boston, most of the municipalities of eastern Massachusetts use ground water as sources of supply. The most recent addition to Boston's supply, the development of Quabbin Reservoir, with a watershed area of about 186 square miles, should supply metropolitan Boston for many years unless some unforeseen change greatly increases the population or use of the water. The major problem is not the scarcity of sources of supply, but the early, preservation of adequate watersheds, taking into consideration a logical plan of conservation and other land uses. In general, the water used for domestic purposes is of satisfactory quality and is safeguarded by frequent examinations and inspection of the sources of

*Massachusetts Senate Document No. 289, 1918, "Report on the Water Resources of the Commonwealth".

supply by the Massachusetts Department of Public Health.

The concentration of mineral matter and presence of bacteria in water have assumed increasing importance in water resource studies during recent years, with recognition of their relation to problems of water supply, while the extensive pollution of some of our streams seriously affect recreation and wildlife conservation. Three major types of measurements have been developed: waters are now analyzed for (1) the occurrence of chemical elements, (2) bacteria, and (3) materials in suspension. These problems are efficiently handled by the State Department of Health.

Industrial:- The problem of industrial water supply is somewhat different because of its intimate relation to the problem of waste disposal. Many industries which originally established themselves in Massachusetts did so because of the need for a dependable supply of clean water. In the early days these industries took their process water directly from the rivers, using it without necessity for treatment. Now, however, with many municipalities and industries discharging untreated sewage and industrial wastes into the streams, it is increasingly difficult to find good supplies, and the industries are forced either to seek location elsewhere, to install expensive individual water treatment plants or to purchase water from municipal plants. The problem of industrial supply is, therefore, one of considerable economic importance and demands immediate attention.

4. Pollution

Domestic Sewage:- Out of 355 cities and towns in Massachusetts 35, with population representing 17 per cent of the total, discharge their sewage untreated into inland streams. In addition, approximately 12½ per cent of the population, representing 234 towns, have no public sewerage system, but in many instances have various outlets which discharge raw sewage into the streams. The discharge of sewage into the rivers and brooks has a deleterious effect upon the quality of the water, especially in dry seasons when the flow is low, hence the question of sewage disposal and stream pollution is closely related to water supply as well as to recreation. The Department of Public Health does not look with favor upon taking for drinking purposes surface water which has been exposed to any considerable amount of pollution.

Sometimes these conditions can be handled by local authorities, but in many instances the nuisances create serious problems not at the point of origin but at some distance down stream in other municipalities. The problem thus becomes one of inter-community action, and should be solved in conjunction with state supervision.

The State Department of Health is well aware of the deplorable sanitary conditions, but under present law lacks the proper author-

ity to deal adequately with the situation. In 1935 a Health Commission was created by the Govenor, and continued under Chapter 12 of the Resolves of 1936. This was an unpaid commission composed of a selected committee of the highest standing. See Page 12, House No. 1200, 1937, filed December 2, 1936. This report said, in part:

> "It is no exaggeration to state that the Massachusetts Department has less authority than that of any other State Department in the United States. This situation has been a logical outgrowth of the fundamental political tenet of the Commonwealth, namely, local autonomy. It was conceived as a department advisory body, the purpose of which was to assist rather than direct the local health boards. The Department was, therefore, given a minimum of authority, and today possesses only those powers specifically delegated to it; all other health authority being retained by the local community. A half century ago, before the development of modern methods of rapid transportation, the public health problem was essentially local, whereas today there are almost no health problems which do not have some intercommunity aspects. The lack of state power has made it possible for some local boards of health to neglect certain duties."

The State Department of Health has lived up to the limit of its authority in the various watershed areas. It has acted in an advisory capacity, has made plans and studies and has made recommendations for the abatement of pollution nuisances, but it is often powerless to enforce these recommendations.

Industrial Waste:- Industrial pollution has been too easily tolerated. No adequate laws or agencies exist to control it, and in consequence it has already ruined many streams, and unless checked will continue its progressive destruction. Many industrial plants constitute nuisances and serious threats to the public health through discharge of industrial waste direct into streams. The deleterious matter ranges from unsightly solids to chemical wash waters or dyes. Each plant or process is a separate problem, and the solution often means delving into unexplored fields of chemistry. Progress has been made in some fields, and methods have been developed for alleviating certain industrial pollution. It is often true that "Today's waste may be tomorrow's by-product". Some methods, of course, show costs so high that their economic use cannot be considered. Where no by-product can be found waste treatment or disposal becomes just another item of overhead.

It should be emphasized that the process of restoring the waters of a stream to their original purity is not always good judgment or sound economy. Certain streams are primarily industrial in character and function principally as a means for the disposal

of reasonable quantities of wastes. So long as such wastes do not become a menace to public health,create unduly offensive conditions or seriously impair the rights of other users, it is difficult to see that these streams serve a less useful purpose than if restored to original purity for recreational or other purposes. It can be stated, however, that much of the present industrial pollution need not and should not be tolerated. Chambers of Commerce and other civic agencies negotiating for new industrial establishments should investigate the type and amount of industrial waste which will be discharged by prospective industries as compared to the amount of money they contribute in payrolls and taxes. It may well be that a new industry which appears to be acquisition may turn out to be a liability and would injure existing industries along the same stream as well as other assets of the community.

Pollution laws have been passed in many states. In 1935 the neighboring state of Connecticut passed legislation covering stream pollution. The State Water Commission is the enforcement agency on the grounds that pollution of a waterway is contrary to the policy of the state. The Act provides, however, that the state must show how any type of waste can be treated, and that "the cost of installing, maintenance and operation shall not be unreasonable or inequitable". It was recognized that strict enforcement of a general rule demanding complete treatment of waste discharge might not only unjustly overtax certain industries but actually drive them out of business. Any arbitrary ruling on industrial pollution may easily operate so as to place in the hands of the enforcement officers the life or death of an industry. The steady overtaxing of the streams, the reduction of fish life and the creation of unsightly areas and odors are direct infringements on the rights of other riparian owners. Other properties are menaced, property rights are affected, sometimes ruined. These raise problems often difficult of solution. It is possible that special research will have to be subsidized by national contribution before specific recommendations or possible solutions can be offered.

There is agitation by conservationists and such bodies as the American Wildlife Institute, the American Fisheries Society, Isaac Walton League and others who urge the passage of an Act which will establish a permanent government agency placing pollution problems under Federal authority. Anti-pollution work may sooner or later be taken up as a Federal concern. Several bills are now before Congress, and undoubtedly will receive Federal sanction in some form. It is generally believed that action best suited to the needs and sentiment of New England can be obtained more quickly on interstate water problems through interstate compacts that will provide direct authority in each state than otherwise.

5. Irrigation and Drainage

Because of the comparatively uniform distribution of an adequate

rainfall throughout the year there are no irrigation problems for large areas in the state. Special crops requiring local irrigation are not considered a state problem.

Generally speaking, land drainage is confined to the coastal areas and to the lowlands and swamp areas, particularly near population and recreation centers, where the question of mosquito control arises. There has been some adverse criticism by conservationists of the drainage of large areas. Large sums of money have been appropriated for drainage, for purposes of mosquito eradication or for reclamation alone,but protests have been made by those concerned especially with the conservation of wildlife. It is conceded that drainage is the only means to be used under certain conditions; however, it has often been destructive of the value of some areas whose true value is for wildlife. It has been pointed out that when the marshes are drained and the water table lowered the aquatic creatures and the animals feeding on them die. Much drainage has been done on the major bird migration routes, and many marshes which formerly supplied important water rest areas, food and cover for the birds have been dried up. There has even been suggested an active educational program designed to stem the drainage tide and to bring about the restoration of certain marsh and swamp areas. Thus when large areas of swamp land are considered for drainage it is possible that some sort of a compromise should be made, or the work done in conjunction with the conservationists. There is no doubt, however, that in some localitites mosquito control will be the dominating factor,leaving the more isolated areas for conservation purposes. Full reconciliation of these conflicting purposes may be arrived at through discovery of a method of eleminating mosquito larvae from standing water without injury to its quality as affecting vegetation or animal life. This is the problem of the wildlife conservationists.

6. Water Recreation and Wildlife

There has been a growing demand in recent years for an improved quality of water in streams or ponds devoted in any degree to recreational uses. Swimming, and picnicking along the banks, is potentially dangerous in waters into which domestic sewage is discharged, yet very few streams in regions where population is even moderately dense can meet reasonable standards of purity for recreational uses.

There has been a growing sentiment in recent years for an improved quality of water in our streams in order that they may be more desirable for recreational uses. This has been especially true in the Connecticut and Housatonic River valleys, where local organizations and the newspapers have aroused considerable interest in this problem.

There is no doubt that certain waters in many parts of the state

may be profitable and properly developed for water sports, such as boating, swimming, motor boat racing and allied sports, and that any complete study of a river must include the consideration of recreational opportunities. It is probable that large areas of watersheds now reserved for public water supply might be developed as game refuges,or under careful regulation and supervision for limited recreational use.

It must not be forgotten, however, that there are two factors to be weighed one against the other: (1) the encouragement and development of industries which may use these waters for manufacturing purposes and for the discharge of partially treated wastes, (2)the advancement of various forms of recreation and the encouragement of wildlife on and in these waters through the removal of various sorts of pollution. In any program aiming at the promotion of the latter class of use due consideration should be given to its effect upon the former, making sure that it will not result in the driving out of the Commonwealth industries which employ large numbers of our wage earners.

7. Navigation

There are no inland waterways of commercial importance within the state. Except for one or two short stretches of coastal streams close to tidewater, commercial navigation is confined to the ocean waterways and the many excellent harbors, estuaries, and tidal sections of rivers.

The dredging or deepening of ship channels, anchorages, construction of breakwaters or jetties,sea walls for protection against beach erosion, and allied salt water problems are not considered in the drainage basin studies, but will be discussed as a distinct and separate subjects in other reports by the State Planning Board.

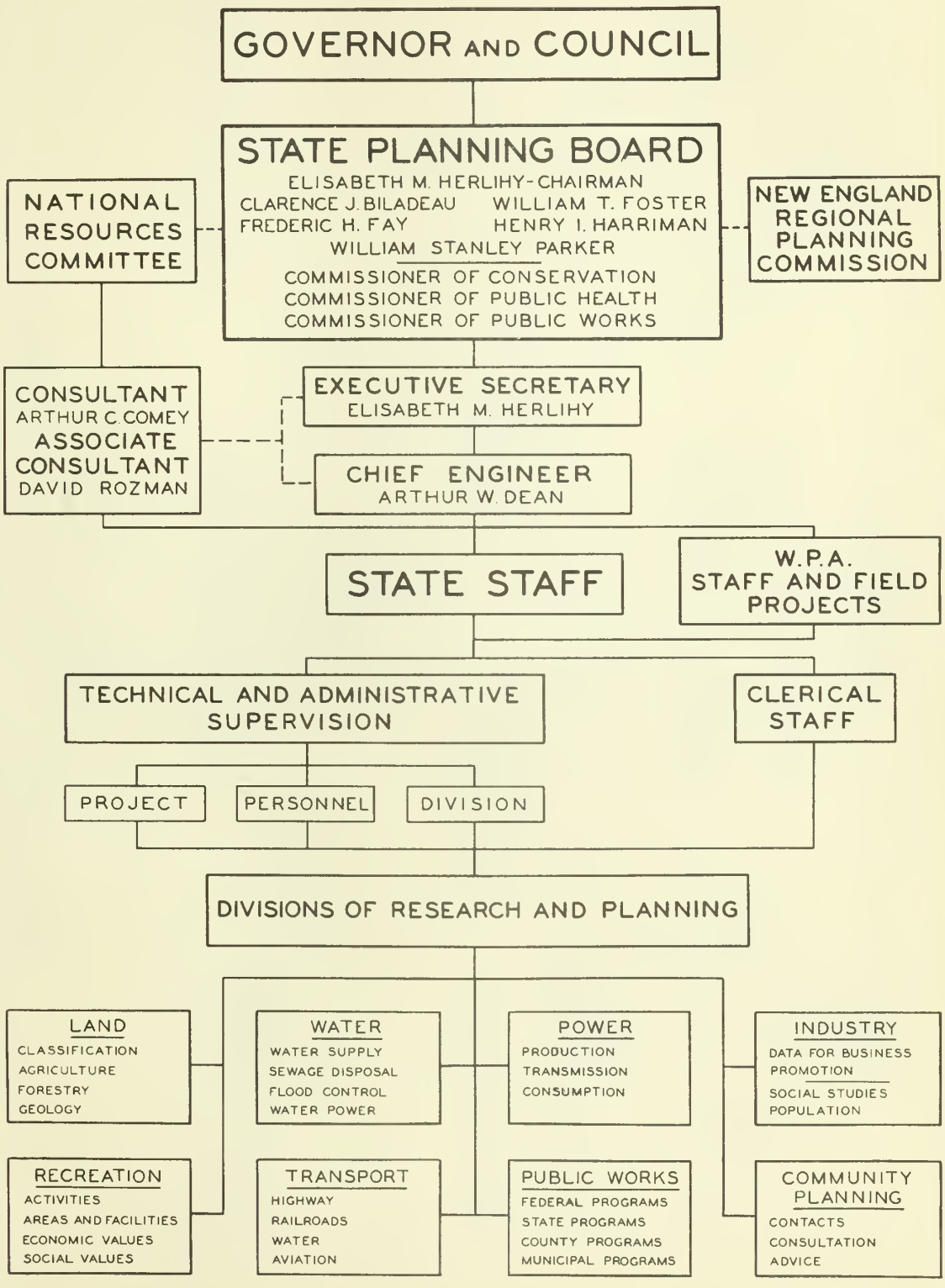
C. Administrative Organization and Procedure

The staff for the Water Resources study is one of a number provided by the Works Progress Administration State Planning Projects sponsored by the State Planning Board. The organization of these is indicated on the accompanying chart.

The present Water Resources studies, together with Pollution studies sponsored by the Massachusetts Department of Public Health, were in operation from February 18, 1937, to July 1, 1937, and from August 16, 1937, to date. Preparatory work had been done on similar studies under earlier projects. Subordinate subjects have been, and some still continue to be, sources of original data,new or corrective.

For purposes of administration, co-ordination and efficiency of operation, the state was divided into three districts, East, Central and West. The Eastern district extends from the Atlantic

# MASSACHUSETTS STATE PLANNING BOARD ORGANIZATION

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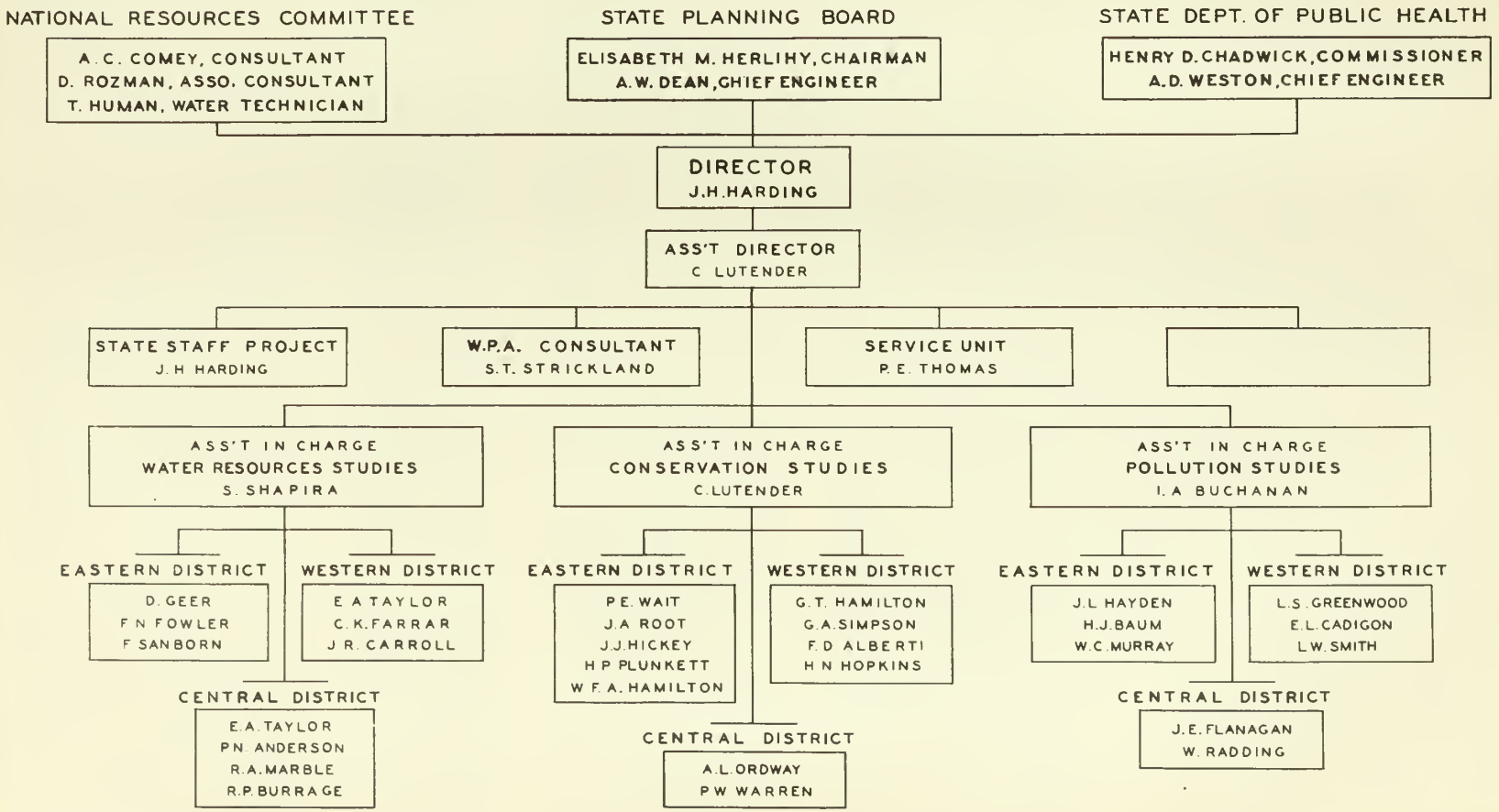
# W.P.A. STATE PLANNING PROJECTS

## 175 CONGRESS STREET

## BOSTON MASS.

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Ocean to the eastern divide line of the Merrimack and Blackstone watersheds. This district includes the following river basins: Parker, Ipswich, Mystic, Charles, Neponset, Taunton, Weymouth and Ten Mile, besides the coastal drainage areas. The Central district has as its eastern boundary the western divide line of the Eastern district, and as its western boundary the east divide line of the Connecticut River valley. This district includes the following river basins: French, Quinnebaug, Merrimack, Nashua, Concord, Assabet and Blackstone. The Western district has as its eastern boundary the western divide line of the Central district, and as its western boundary the Massachusetts-New York state line. This district includes the following river basins: Housatonic, Hoosic, Connecticut, Deerfield, Westfield, Farmington, Millers and Chicopee.

Field offices were set up as follows: in Boston for the Eastern district; in Worcester and Fitchburg for the Central district, and in Springfield and Pittsfield for the Western district. A supervisor was placed in charge of each district. Each office was provided with personnel for clerical, drafting and engineering studies, as well as with field survey parties. No field work has thus far been attempted in the Eastern district due to the lack of sufficient personnel. The Boston office, maintained as Headquarters, directed the work. The co-ordination of the studies was under State Planning Board staff supervision.

The logical order of preliminary activities was followed insofar as permitted by the practical necessity of initiating almost simultaneously field work and research aimed at accumulation of existing data from prior studies. Published documents of previous studies and data in the general subjects of hydrology and allied phases of the problem were searched for sources of pertinent information. Considerable data were transcribed into desired form and used for collation and comparison.

Field work to supplement such basic data properly would follow the discovery of gaps, but the necessity for a large amount of original information regarding precipitation, run-off, existing dams, storage, ponds, and other items in all the basins was immediately so obvious that field parties were profitably set to work as rapidly as they could be organized.

It should be noted here that a most admirable co-operation prevailed from the start among the various departments of the Commonwealth, so that projects whether sponsored by the Department of Public Health or the State Planning Board co-operated toward the common end. In valleys such as the Merrimack and Connecticut, where flood-control studies were being undertaken by the United States Army Engineers, no attempt was made to cover this phase pending their conclusions. However, in these valleys much factual data such as flood damages, stage and discharge records, were made available to the army Engineers, the value of which has, in many instances,

already justified a great deal of the preliminary work done under the various projects.

As the studies progressed the existence of discrepancies and demands for extension of the field studies resulted in the occasional re-direction of activities. Points of outstanding importance reported from the field were studied by the project chiefs and consultants in the course of frequent field visits of inspection.

The ideal always before the staff has been the preparation of a comprehensive study based on reliable data. It is proper to note here that neither time, funds, nor personnel thus far allocated or available have been sufficient to permit all details to be gone into as extensively as might be desired. Federal restrictions and the method of assembling field and office personnel cannot be sufficiently selective to bring together a group of uniformly trained technicians. Procedure, outlines of studies and demands on individuals have been modified to meet these limitations. However, the studies have been sufficiently reliable and comprehensive to permit general conclusions and recommendations.

When all of the basin studies are completed a summary will be issued covering problems and proposals for solution confronting the state as a whole.

# MASSACHUSETTS DRAINAGE BASIN STUDIES

## DRAINAGE BASIN STUDY NO. 1 - BLACKSTONE RIVER

## SUMMARY

The Blackstone River Basin, located in South Central Massachusetts, has an area of 232 square miles and a population of approximately 255,000. General slope is toward the southeast. Elevations vary from 1360 feet in the wooded highlands around Worcester to about 100 feet in the level cultivated lowlands in the southern portion of the Basin. The region, greatly enhanced by excellent water power sites, was virtually the cradle of American industry and is now an important industrial area of the State.

The March,1936 flood caused direct losses in the valley amounting to $1,609,153, or $6.40 per capita,of which the damage to stock and power equipment accounted for a great proportion. Much of the damage sustained can be attributed to local negligence in permitting refuse and other waste material to be dumped into the river,or permitting other damage-provoking conditions to exist. A recent inspection of the river showed deplorable neglect. Encroachment on the channel and the dumping of refuse into the river should cease. A patrol system could be inaugurated by the various communities to prevent the creation of such flood hazards.In sections where houses have been built on the flood plain, the height attained by the 1936 flood should be prominently marked, and consideration should be given to the use of zoning as a means of restricting the occupation of areas subject to periodic inundation.

Worcester, the most populous center in the valley,was seriously affected. Suffering a flood loss of $700,000, or 43 per cent of the total damage, in the March, 1936 flood, it is an important factor to be considered in a flood-control program. The city, located in a portion of the watershed which drains 60 square miles (18 per cent of the basin), has no economical sites available for the construction of detention basins, and the problem necessitates flood-control measures such as conduit construction, by-passing creek flows, and allied methods which have little or no benefit to down stream municipalities. Its problems, therefore, are primarily a matter of local measures, some of which would probably be classified as local improvements to justify the expenditures.

The construction of detention basins for flood-control purposes is not economically justified for the Massachusetts area of

the basin. Justification might possibly be shown by further study if interstate problems of power, low water control and other uses are considered.

The Blackstone River is one of the most completely developed streams in the world. Not only has the main stream been fully developed, but practically all the potential power on the tributaries has been used at one time or another. The few undeveloped sites which remain are of negligible importance.

Public water supply conditions in the valley are generally satisfactory. Only five towns lack satisfactory water supplies: Blackstone, Sutton, and Upton, with partial supplies; Mendon and Millville, with none. Industrial supplies originally taken from the River have been greatly jeopardized by pollution forcing some industries to seek new supplies elsewhere.

Sanitary conditions in the valley are unsatisfactory due to the heavy pollution from both domestic and industrial wastes, further aggravated by the promiscuous disposal of town refuse and rubbish along the banks. These conditions can and should be improved and such imporvements may be developed through better methods of sewage disposal. Industrial wastes should be handled as a separate problem if river pollution is to be reduced without placing undue restrictions on the industrial development of the valley.

Because of the uniform distribution of adequate rainfall throughout the year, there is no need for irrigation except in small isolated areas devoted to the cultivation of cranberries. There are no problems of artificial drainage.

Since the abandonment of the barge canal in 1848, the river has not been used for navigation.

Since the Blackstone River is essentially an industrial stream its recreational possibilities should be subordinated to its industrial development. A few of the head water bodies and streams offer limited opportunities for further development of bathing, boating and fishing facilities. In general, however, recreation improvements should be confined to the development of forest or park areas where principal attractions are opportunities for picnicking, camping, hiking and winter sports.

# C H A P T E R I

## DESCRIPTION OF THE WATERSHED

### A. Location

The Blackstone basin is located in south central Massachusetts, occupies the southeastern part of Worcester County and skirts the edge of Middlesex, Norfolk and Bristol counties. It lies between the French, Nashua and Sudbury River basins. In Rhode Island it occupies the northern and eastern portion of the state.

### B. Size

The entire basin is 41 miles long and averages 13 miles wide, with a total area of 492 square miles (excluding Ten Mile River), of which 334 are in Massachusetts and 158 in northern Rhode Island.

### C. Physiography

The basin, which has a general slope and drainage toward the southeast, is part of the southeastern portion of the central uplands, and the southwestern portion of the eastern lowlands. There is considerable variation in topography, elevations varying from an extreme of 1,360 feet above sea level in the hill area north and west of Worcester, to 160 feet where the Blackstone River crosses the Massachusetts-Rhode Island line. The northern, or upland portion, is mostly rolling, with many rough and rocky hills. The southern, or lowland portion, is much more subdued, with large areas of comparatively level land.

Geologically, the soils are comparatively young, made up of drift accumulated during the latter part of the last glacial period. Surface and underlying rock is of gray granite, genisses and schist. Stony and sandy soils predominate in the southern section of the valley, and are also common in the northern portion. Due to its glacial origin, the soil in the upper or hilly section is thin - often with a prevalence of rock - making agriculture unprofitable under modern conditions. In the early days, after clearing from

the primitive forest, much of this land was cultivated in small irregular patches, until the virgin fertility of the soil was exhausted. The difficulty of working this type of soil in competition with the richer land of the western farms is the principal reason for the abandonment of agriculture on much of the broken land, and its consequent reversion to wood lots or forest. Portions, however, have been profitably used for pasturage,truck farming and part-time gardening.

The basin contains one large lake, Lake Quinsigamond; area 0.853 square miles, located partly within the City of Worcester. However, smaller ponds and reservoirs are numerous. In the Massachusetts portion of the drainage basin they aggregate about 9.2 square miles, or 2.7% of the drainage area. (See Table 12-Principal Lakes and Ponds on the Blackstone River in Massachusetts, Page 34).

Because of the frequent and abrupt changes in elevation, the Blackstone River makes sharp descents at numerous places, forming waterfalls where it passes over rocky ledges. These waterfalls are in most instances the result of the movements of glacial ice which blocked the old channel of the stream and forced it into a new course across rocky formations, thereby creating numerous natural falls which offered favorable power sites. This convenient power attracted the early establishment of textile industries, and resulted in the location and growth of numerous towns and villages along the stream. Some of these sites are among the earliest water power developments in the United States. Many have now been abandoned or carried away by floods.

D. Cover

Much of the watershed is wooded, although large areas are under cultivation or are taken up in thickly settled villages, towns, and the City of Worcester. An approximate idea of the cover is given in the following table, taken from a State Planning Board land utilization map of the Blackstone River watershed:

Table 1

| | |
|---|---|
| Woodland | 61% |
| Pasture | 8% |
| Hay and Crop Land | 15% |
| Orchard and Truck Land | 2% |
| Residential, Industrial and Commercial | 7% |
| Reservations | 2% |
| Swamp | 1% |
| Water | 4% |

Part of the wooded area is of potentially merchantable species in both hard wood and coniferous varieties. This includes considerable sprout growth on land which has been cut over and allowed to grow up with no attempt at forestry management. Pasture, hay and crop land include many small farms as well as large dairy farms. Orchard and truck land areas are, for the most part, large farms. The percentage of residential, industrial and commercial areas is high because of the presence of the city of Worcester. Reservation area is chiefly due to the large number of parks and other public areas in the city. Classified under reservations are also cemeteries, town parks, recreation areas and the Purgatory State Park in Sutton. State forests are not included. Swamp areas included are only those which are waste land - neither wooded nor otherwise utilized. Water area includes all lakes, ponds and larger streams.

E. Climate

The distinguishing climatic feature of the valley is variability. The mean annual temperature for the city of Worcester for the period from 1893 to 1932,inclusive, was 48° F. The highest reported mean monthly was 71.3° F., and the lowest was 24.9° F. The valley has a remarkably even distribution of rainfall. In an article entitled "Distribution of Rainfall in the Eastern United States", B. C. Wallis states, "The rainfall of this belt (Blackstone valley) is marked by a comparative steadiness of precipitation throughout the year. It forms a striking example of the phrase 'rainfall at all seasons' ". The northern and southern portions of the watershed have an annual rainfall of 46 to 47 inches;the central portion has between 43 and 44 inches,and the yearly average for the 47-year period from 1888 to 1935 was 44.63 inches. The maximum and minimum yearly rainfall,as determined from a single station, was 61.8 inches and 28.43 inches, respectively. The month of March, 1936, showed an all-time record for precipitation in the upper portion of the valley. The average rainfall was 11.64 inches for the towns of Leicester, Holden, and the city of Worcester, but it was somewhat less in the lower portion of the valley, and 10.62 inches was recorded at Northbridge. Approximately 70% of this rainfall was between March 11 and 19.

The most severe storms, as recorded by the Winter Hill Meteorological Observatory in Worcester, are given in the following table:

Table 2

RECORD STORMS

(Inches of Rainfall)

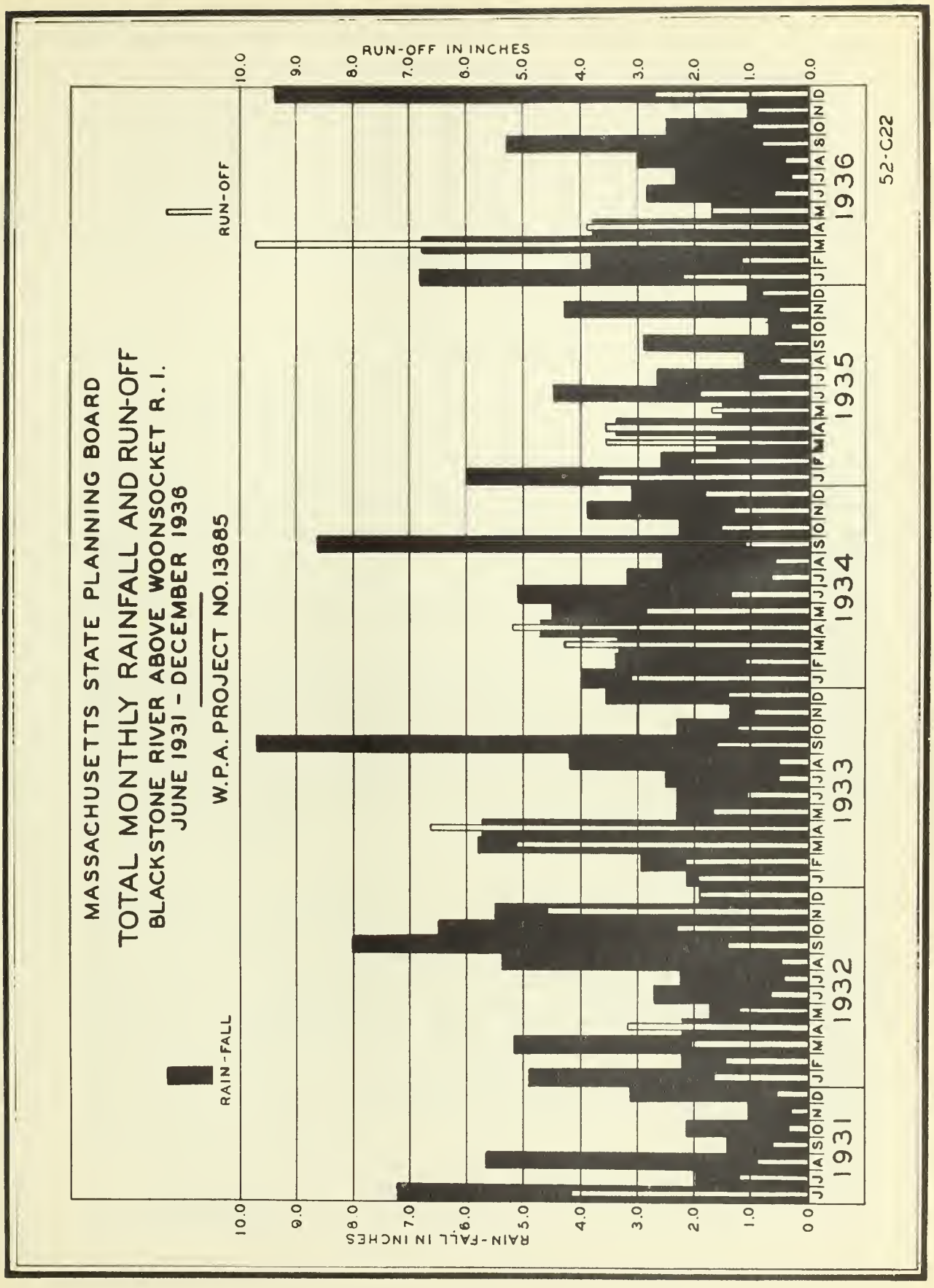
| | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1900 | | 3.16 | | | | | | | | | | |
| 1905 | | | | | | | | | 5.31 | | | |
| 1915 | | | | | | | 3.23 | | | | | |
| 1920 | | | | | | | | | 5.16 | | | |
| 1923 | | | | | | | | | | | 4.20 | |
| 1927 | | | | | | | | | | | 5.17 | |
| 1931 | | | | | | | | | | 5.31 | | |
| 1932 | | | | | | | | | 5.59 | | | |
| 1933 | | | | | | | | | 6.49 | | | |
| 1936 | | | 9.02 | | | | | | | | | |

Below are listed previous severe storms, data for which is extremely meagre:

| | | |
|---|---|---|
| July 23-24 | 1830 | No details available |
| Oct. 4-5 | 1869 | No details available |
| Mar. 28-30 | 1876 | "A number of dams burst in the Valley" |
| Feb. 19 | 1886 | "This flood was the greatest within the last 60 years at Wendon" |
| Dec. 10 | 1878 | "On this date 3.18 inches of rain fell" |
| Oct. 12-14 | 1895 | "This storm was next to 1927 storm in size" |

F. Run-off

The mean annual run-off within the valley is 21.7 inches, which is approximately 48% of the mean annual precipitation. See Paragraph E Page 3.


MASSACHUSETTS STATE PLANNING BOARD
TOTAL MONTHLY RAINFALL AND RUN-OFF
BLACKSTONE RIVER ABOVE WOONSOCKET R.I.
JUNE 1931 - DECEMBER 1936
W.P.A. PROJECT NO. 13685
RAIN-FALL
RUN-OFF
RAIN-FALL IN INCHES
RUN-OFF IN INCHES
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1931
1932
1933
1934
1935
1936
52-C22

# C H A P T E R II

## HUMAN OCCUPANCY

### A. Historical Sketch

The river takes its name from William Blaxton, better known as Blackstone, the eccentric hermit of Shawmut, the first settler on the site of Boston, who had moved into what is now called Central Falls, Rhode Island, and fled the territory on the advent of other settlers in 1634, moving in to the wilderness to a place called "The Gore", now Cumberland, Rhode Island. His orchards produced the first apples raised in America.

The basin contains some of the oldest established towns in the Commonwealth, and since Colonial days has been of great industrial importance. Here lived Eli Whitney, inventor of the cotton gin; here the textile industry had its beginning; the first piano wires in America were drawn,and the carpet machine, the first typewriter, the power loom for weaving fancy textiles, and the machine lathe for turning irregular forms, etc., were invented. The region was virtually the cradle of American industry, and has continued to develop ever since.

Worcester, second largest city of the Commonwealth, is the largest city in the basin. It was first permanently settled in 1713. The first grant of land was bought from the Indians in 1657. This settlement was burned several times, and abandoned during Queen Anne's and King Philip's Wars. The old Common, originally dedicated as a meetinghouse site, was the training ground of "Minute Men". In 1849 Worcester became incorporated as a city. One of its largest industries, the American Steel & Wire Company, dates from 1831, and owes its start to the hoopskirt. During the height of fashion it turned out 30 tons of hoopskirt wire a week. Worcester was the first city in the county to purchase and set aside land for park purposes.

At Woonsocket,settled in 1666, the first sawmill in the valley was established.

B. General Character

Most of the towns are industrial in character, and nearly all are located along the Blackstone, West and Mumford Rivers. The Blackstone River is one of the most completely developed streams in the world. Out of a total fall of 471 feet, (at Worcester Electric Light Company) extending from the city of Worcester to the outlet of the river in Rhode Island, 409 feet are utilized. There are 32 dams on the main stream,and numerous power and storage developments on the tributaries.

The character of the agricultural development of the valley has changed considerably in the past 75 years. In common with similar agricultural areas of the east, it shared in the general movement toward the abandonment of farm land which occurred throughout New England during the latter part of the 19th century.

1. Population

There are twenty-eight (28)towns and two (2)cities whose areas lie wholly or partly within the Massachusetts portion of the watershed. The principal city is Worcester,with a population of 190,471. Only eight of the other towns in the watershed have a population of more than 5000. In 1935 the total population of the watershed was 255,004, representing a growth of about 32.2% in the last 25 years. This rate will probably slow down considerably as the industrial development of the basin reaches maturity. The city of Worcester,which represents 75% of the population of the valley, has shown the greatest increase in population since 1910, with a growth of nearly 30.5%. The population in some of the towns has remained practically the same since 1850,and a few have actually shown losses - the town of Sutton as much as 22%. Tables 3 and 4, giving information regarding size and population, together with area within watershed, indicates the general trend in population growth from 1900 to 1935.

2. Industry - Urban and Decentralized

Practically all of the towns are industrial in character. The city of Worcester is one of the most diversified manufacturing centers of the east,the chief manufacturing being cotton and wool textiles, steels, machine tools, instruments and wire. Even in 1934 (not a peak year) its varied industries produced products valued at close to $110,000,000, and paid out to employees about $28,000,000 in wages. In 1936 the total assessed valuation of the property for the whole valley was approximately $404,875,092, and of this 71% was in the city of Worcester. Quarrying is of minor importance.

### 3. Agriculture and Forestry

Farms in the Blackstone valley number about 1,200. The density of the rural population is approximately 25 per square mile. Although over half the area of the watershed is listed as in farms, 50% of this is actually wood lots. The average value of farms, land and buildings, is somewhere near $100 per acre, with farm buildings in generally good condition, although some deterioration has taken place during the depression years.

Dairy farming is by far the most important, followed by fruit growing, vegetables for local markets, and poultry. Small general farms grow produce for their own consumption and sell their surplus, together with a few crops grown for market. Farming methods are slowly improving, and, with proper encouragement, will continue to increase production, without the soil depletion which took place in former years.

Many of the farms, most of which are small, have been taken up in the last few years by foreign-born, principally Poles and Lithuanians, who often operate them as a family enterprise. In cases where labor is employed it is usually of seasonal duration, although on dairy farms labor is hired by the year. Most of the hired help is employed in the dairies, orchards, market gardens and nurseries.

Lumbering is practically unknown. However, occasionally timber and the larger trees from wood lots that are cut off for firewood furnish material for the operation of a few small sawmills.

### 4. Transportation

Waterways. No portion of the Blackstone River in Massachusetts is navigable.

Highways. The region is well served by existing highways. Through routes No. 1 (U. S.) and No. 9 (Mass.) to New York cross the river valley at Providence and Worcester.

Railroads. The principal population centers are all adequately served by rail transportation. Two main lines cross the valley, the Boston & Albany via Worcester, and the N. Y. N. H. & H. via Providence. Both carry very heavy traffic. There are two secondary routes, the Providence and Worcester branch of the N. Y. N. H. & H., which parallels the river, and the so-called airline route of the N. Y. N. H. & H. through Blackstone and Douglas.

Airways. There are two airports in the Massachusetts portion of the valley; Grafton, which serves the Worcester region, and a small auxiliary field at Mendon. The Massachusetts tentative plan * for airways and airports recommends Grafton and Mendon as sites for development of airports of primary importance.

C. Past Trends and Future Possibilities - Urban and Rural

The development of the small towns was influenced by favorable water power sites, while the phenomenal growth of Worcester was due to its excellent position as a transportation center. The real development of the region began with the improvement of roads and turnpikes about 1800, the opening of the Blackstone Canal** in 1828, and the advent of the railroad in 1835. During recent years farms have increased in number and population, and a strong tendency toward the further development of truck and part-time farming, due to the accessibility of large markets, is now discernible. At the present time dairies and orchards are growing in number and area. This trend may well be expected to continue, since much of the topography and soil is particularly suited to these types of agriculture. The more important increase, however, will be in production due to better management. Poultry raising is also expanding, and may continue to increase in importance.

In general, the future of the valley will continue to be dependent upon its industrial activity, but no longer will the necessity of close proximity to water power play such an important part. Granted reasonable access to raw materials, and the presence of large markets, the Blackstone valley, with its already well-established and adequate means of transportation, both highway and railway, will probably continue further industrial growth in the future, but at a much slower rate.

*See Massachusetts State Planning Board 1936 Progress Report Map 76-12.
**See History of Blackstone Canal, Appendix B.

Table 3

BLACKSTONE RIVER BASIN

| TOWNS | TOTAL AREA SQ.MI. | AREA WITHIN WATER-SHED | TOTAL POPU-LATION 1935 | TOTAL POPU-LATION 1910 | ESTIMATED POPULATION WITHIN WA-TERSHED AS OF 1935 | PER CENT INCREASE SINCE 1910 |
|---|---|---|---|---|---|---|
| Attleboro | 27.77 | 1.00 | 21,835 | 16,215 | 100 | 34.7 |
| Auburn | 16.44 | 15.38 | 6,535 | 2,420 | 6,535 | 170.0 |
| Bellingham | 18.91 | 9.39 | 3,056 | 1,696 | 2,100 | 80.2 |
| Blackstone** | 11.29 | 11.29 | 4,588 | 5,648 | 4,588 | ** |
| Boylston | 19.77 | 3.88 | * | * | * | * |
| Douglas | 38.08 | 31.44 | 2,403 | 2,152 | 2,163 | 11.7 |
| Franklin | 27.00 | 2.80 | * | * | * | * |
| Grafton | 23.32 | 21.73 | 7,681 | 5,705 | 7,681 | 34.6 |
| Holden | 36.20 | 6.45 | * | * | * | * |
| Hopedale | 5.26 | 4.21 | 3,068 | 2,188 | 2,600 | 40.2 |
| Hopkinton | 27.92 | 3.42 | 2,616 | 2,452 | 508 | 6.7 |
| Leicester | 24.52 | 9.87 | 4,426 | 3,237 | 1,476 | 36.7 |
| Mendon | 17.94 | 17.85 | 1,265 | 880 | 1,200 | 43.7 |
| Milford | 14.99 | 2.13 | 15,008 | 13,055 | 500 | 15.0 |
| Millbury | 16.38 | 16.38 | 6,879 | 4,740 | 6,879 | 45.1 |
| Millville** | 4.97 | 4.97 | 1,901 | ** | 1,901 | ** |
| N. Attleborough | 19.45 | 4.03 | 10,202 | 9,562 | 215 | 6.7 |
| Northbridge | 17.96 | 17.96 | 10,577 | 8,807 | 10,577 | 20.1 |
| Oxford | 27.39 | 0.78 | * | * | * | * |
| Paxton | 15.40 | 3.91 | 731 | 416 | 122 | 75.7 |
| Plainville | 11.48 | 1.33 | * | * | * | * |
| Shrewsbury | 21.83 | 13.59 | 7,144 | 1,946 | 3,520 | 267.1 |
| Sutton | 33.95 | 33.12 | 2,408 | 3,078 | 2,408 | -21.8 |
| Upton | 21.81 | 20.99 | 2,163 | 2,071 | 2,163 | 4.4 |
| Uxbridge | 29.83 | 29.83 | 6,397 | 4,671 | 6,397 | 36.9 |
| Webster | 14.50 | 0.13 | * | * | * | * |
| Westboro | 21.51 | 0.25 | * | * | * | * |
| W. Boylston | 13.78 | 1.40 | * | * | * | * |
| Worcester | 38.50 | 38.40 | 190,471 | 145,986 | 190,471 | 30.5 |
| Wrentham | 22.68 | 6.06 | 4,160 | 1,743 | 900 | 138.7 |
| Totals | 640.83 | 333.97 | 315,514 | 238,668 | 255,004 | 32.2 |

*Negligible
**Millville was a part of Blackstone until 1916.

Table 4

BLACKSTONE RIVER BASIN

Comparative Growth

| TOWNS | 1900 | 1905 | 1910 | 1915 | 1920 | 1925 | 1930 | 1935 |
|---|---|---|---|---|---|---|---|---|
| Attleboro | 11,335 | 12,702 | 16.215 | 18,480 | 19,731 | 20,623 | 21,769 | 21,835 |
| Auburn | 1,621 | 2,006 | 2,420 | 3,281 | 3,891 | 4,927 | 6,147 | 6,535 |
| Bellingham | 1,682 | 1,686 | 1,696 | 1,953 | 2,102 | 2,877 | 3,189 | 3,056 |
| Blackstone | 5,721 | 5,786 | 5,648 | 5,589 | 4,299 | 4,802 | 4,674 | 4,588 |
| Douglas | 2,113 | 2,120 | 2,152 | 2,179 | 2,181 | 2,363 | 2,195 | 2,403 |
| Grafton | 4,869 | 5,052 | 5,705 | 6,250 | 6,887 | 6,973 | 7,030 | 7,681 |
| Hopedale | 2,087 | 2,048 | 2,188 | 2,663 | 2.777 | 3,165 | 2,973 | 3,068 |
| Hopkinton | 2,623 | 2,585 | 2,452 | 2,475 | 2,289 | 2,580 | 2,563 | 2,616 |
| Leicester | 3,416 | 3.414 | 3,237 | 3,322 | 3,635 | 4,110 | 4,445 | 4,426 |
| Mendon | 911 | 922 | 880 | 933 | 961 | 1,030 | 1,107 | 1,265 |
| Milford | 11,736 | 12,105 | 13,055 | 13,684 | 13,471 | 14,781 | 14,741 | 15,008 |
| Millbury | 4,460 | 4,631 | 4,740 | 5,295 | 5,653 | 6,441 | 6,957 | 6,879 |
| Millville | * | | | | 2,224 | 2,366 | 2,111 | 1,901 |
| N.Attleborough | 7,253 | 7,878 | 9,562 | 9,398 | 9,238 | 9,790 | 10,197 | 10,202 |
| Northbridge | 7,036 | 7,400 | 8,807 | 9,254 | 10,174 | 10,051 | 9,713 | 10,577 |
| Paxton | 459 | 444 | 416 | 471 | 489 | 591 | 672 | 731 |
| Shrewsbury | 1,626 | 1,866 | 1,946 | 2,794 | 3,708 | 5,819 | 6,910 | 7,144 |
| Sutton | 3,328 | 3,173 | 3,078 | 2,829 | 2,578 | 2,174 | 2,147 | 2,408 |
| Upton | 1,937 | 2,024 | 2,071 | 2,036 | 1,693 | 1,988 | 2,026 | 2,163 |
| Uxbridge | 3,599 | 3,881 | 4,671 | 4,921 | 5,384 | 6,172 | 6,285 | 6,397 |
| Worcester | 118,421 | 128,135 | 145,986 | 162,697 | 179,754 | 190,757 | 195,311 | 190,471 |
| Wrentham | 2,720 | 1,428 | 1,743 | 2,414 | 2,808 | 3,214 | 3,584 | 4,160 |
| TOTALS | 198,953 | 211,286 | 238,668 | 263,018 | 285,927 | 307,594 | 316,746 | 315,514 |
| Per cent of Increase or Decrease | | 6.2 | 13.0 | 10.2 | 8.7 | 7.6 | 3.0 | -.4 |

NOTE 1:- In the above table the fact that the entire town does not in all cases lie within the watershed has been disregarded. The table lists the total population of each town in order to obtain for comparative purposes a relative percentage increase or decrease from one census period to the next.

NOTE 2:- Table 4 does not conform to Table 3, which lists areas. Towns having a negligible population, as indicated in Table 3, have been omitted.

*Was a part of Blackstone, Inc. 1916

Table 5

BLACKSTONE RIVER BASIN

| CITIES OR TOWNS | TOTAL VALUE OF ASSESSED TANGIBLE PERSONAL ESTATE | TOTAL VALUE OF ASSESSED REAL ESTATE LAND&BUILDINGS | TOTAL VALUATION OF ASSESSED ESTATE AS OF DEC.1936 |
|---|---|---|---|
| Attleboro* | 3,780,800 | 21,602,205 | 25,383,005 |
| Auburn | 585,200 | 5,402,800 | 5,988,000 |
| Bellingham | 234,370 | 2,075,655 | 2,310,025 |
| Blackstone | 168,975 | 2,165,995 | 2,334,970 |
| Boylston | ** | ** | ** |
| Douglas | 462,982 | 1,369,131 | 1,832,113 |
| Franklin | ** | ** | ** |
| Grafton | 780,355 | 3,361,180 | 4,141,535 |
| Holden | ** | ** | ** |
| Hopedale | 2,031,606 | 2,567,509 | 4,599,115 |
| Hopkinton | 422,700 | 2,405,400 | 2,828,100 |
| Leicester | 377,450 | 2,768,000 | 3,145,450 |
| Mendon | 150,570 | 1,198,230 | 1,348,800 |
| Milford | 1,885,465 | 12,855,000 | 14,740,465 |
| Millbury | 1,835,525 | 3,868,736 | 5,704,261 |
| Millville | 63,419 | 1,032,466 | 1,095,885 |
| N. Attleborough | 1,244,870 | 8,743,840 | 9,988,710 |
| Northbridge | 2,575,172 | 6,033,160 | 8,608,332 |
| Oxford | ** | ** | ** |
| Paxton | 64,113 | 891,904 | 956,017 |
| Plainville | ** | ** | ** |
| Shrewsbury | 752,025 | 7,514,810 | 8,266,835 |
| Sutton | 366,503 | 1,379,595 | 1,746,098 |
| Upton | 242,351 | 1,077,590 | 1,319,941 |
| Uxbridge | 1,680,905 | 5,463,610 | 7,144,515 |
| Webster | ** | ** | ** |
| Westboro | ** | ** | ** |
| W. Boylston | ** | ** | ** |
| Worcester* | 31,653,450 | 255,840,750 | 287,494,200 |
| Wrentham | 528,755 | 3,169,965 | 3,698,720 |
| TOTALS | 51,887,561 | 352,787,531 | 404,675,092 |

*Cities
**Negligible

## CHAPTER III

## STREAMS OF THE BASIN

Table 6

The Blackstone River and its Principal Tributaries

| RIVER | LOCATION | DRAINAGE AREA (SQ. MI.) | LENGTH (MILES) | GENERAL DIRECTION OF FLOW | JOINS MAIN RIVER AT OR NEAR | JOINS MAIN RIVER MILES FROM MOUTH |
|---|---|---|---|---|---|---|
| Blackstone | Mass.& R.I. | 492 | 51.5 | S. E | Main Stream | |
| Quinsigamond | Mass. | 37 | 12 | S. | Fisherville, Mass. | 40 |
| Mumford | Mass. | 58 | 16 | E. | Uxbridge, Mass. | 29.5 |
| West | Mass. | 35 | 13 | S. | Uxbridge, Mass. | 29 |
| Branch | Mass.& R.I. | 93 | 18 | E. | Blackstone, Mass. | 22 |
| Mill | Mass.& R.I. | 34 | 16 | S. | Woonsocket, R.I. | 18 |
| Ten Mile* | Mass.& R.I. | 56 | 16 | S. | E.Providence, R.I. | 2 |

The Blackstone River is the name by which the main stream above tidewater is generally known; the tidal portion is called the "Pawtucket", and below the City of Pawtucket it is known locally as the "Seekonk".

### A. Source

The river is formed near the City of Worcester by the union of Kettle, Ramshorn and Tatnuck Brooks, which unite into a stream

*Excepting Ten Mile River, these tributaries enter above tide water. Ten Mile, however, is not a tidal stream, owing to a low dam built across its mouth. The Ten Mile River, although generally considered a part of the Blackstone basin, is dealt within a seperate report.

known locally as Middle River at South Worcester. Mill Brook channel, which passes through the city as a covered stream, joins Middle River, and from this point of junction the stream is locally called the Blackstone. Kettle Brook, which has the largest drainage area and considered the source, rises on the west slope of Little Asnebumsket Hill at an elevation of about 1,300 feet above sea level.

B. Course

From the city of Worcester the river flows southeasterly, passing through densely populated manufacturing districts. In its course to the sea it flows through the towns of Millbury, Sutton, Grafton, Northbridge, Uxbridge, Millville and Blackstone; crosses into Rhode Island, flowing through the municipalities of Woonsocket, Lincoln, Cumberland, Central Falls and Pawtucket, and empties into Providence Harbor, an arm of Narragansett Bay. The lower five miles of its course is tidal and has a maximum width of half a mile.

C. Length

Measured along its course it has a length of 51.5 miles, 31 miles of which lie in Massachusetts, and 20.5 miles in Rhode Island.

D. Drainage Area

The total drainage area of the basin, excluding Ten Mile River, is 492 square miles,[1] 68% of which is within Massachusetts, and includes all or parts of the towns and cities listed in table 3, page 9.

E. Discharge

From the results of a survey of the valley by the United States Army engineers in 1929 it was found that gaging stations which were in operation at that time gave poor results due to storage and backwater conditions. Records of the U. S. G. S. gaging station at Worcester were inaccurate because of the control exercised by the large number of dams. A gaging station has since been established at Woonsocket and records are available from February, 1929, to date. Due to the short period of record, only tentative discharge values can be given. The following table gives the maximum, minimum and average discharge at the two stations:

[1] This does not include the 9.35 square miles of the Nashua River Basin which has been diverted into the Blackstone Basin for additional water supply for the city of Worcester.

Table 7

| STATION<br>PERIOD OF RECORD | WORCESTER<br>1923-1936 | WOONSOCKET<br>1929-1936 |
|---|---|---|
| Drainage area in square miles | 31.5 | 415.0 |
| Maximum 24-hr. flow, cu. ft. per sec. | 1,490 | 14,000 |
| Maximum peak discharge, c.f.s. | 2,520 | 15,000 |
| Minimum 24-hr. flow, c.f.s. | 1.1* | 21.0** |
| Minimum 7-day flow, c.f.s. | 2.8* | 89.6** |
| Minimum recorded discharge, c.f.s. | 0.3* | - |
| Average discharge for period of record, c.f.s. | 48.4* | 604** |
| Average discharge per square mile, c.f.s. | 1.54* | 1.44** |

Estimates of the discharge of this stream have been made in the past; one by the Massachusetts State Commission on Waterways and Public Lands in 1918, and the other by John R. Freeman in 1906. These estimates were based upon an analogy to the flow of adjacent basins with long periods of record, and the discharges were estimated to be 1.5 and 1.77 second feet, respectively, per square mile of watershed. Assuming 1.6 second feet per square mile as the average rate, the mean discharge for the entire basin would be 864 second feet, while that for the 475 square miles above the first dam at tidewater in Pawtucket would be 760 second feet.

F. Floods

Little information is available about past floods in this valley. The largest flood ever to occur was in 1886, which was slightly higher than the flood of March, 1936. In November, 1927, a large flood occurred, the damage from which amounted to approximately $650,000. Most of the loss, however, was concentrated in the Rhode Island portion of the valley.

The flood of March, 1936, was the second largest ever recorded. Two floods really occurred; the first on March 12 and the second on March 19. Unusual conditions were present during each of these floods. A heavy snow blanket had been held in the upper regions by low temperatures. A sudden rise above freezing caused the rapid melting of this snow, and a heavy rainfall, together with the frozen condition of the ground, caused exceedingly high run-off. The rainfall subsided somewhat between March 13 and 17, but then started again with even greater intensity. The rainfall from March 17

*1923-34
**1929-34

to 19 was approximately 65% greater than the preceding period, but fortunately the largest portion of the snow blanket had been removed during the first flood. However, the peak flow for the second flood was higher than that of the first.

The peak run-off as recorded at the South Works of the American Steel & Wire Company in Worcester was 2,800 second feet for the first flood, and 3,500 second feet for the peak run-off during the second flood. The U. S. G. S. gaging station in Woonsocket reported a maximum run-off for the first of 13,000 second feet, and 15,000 second feet for the second. The run-off per square mile was much higher in the upper valley than in the lower. The run-off of some of the smaller flashy tributaries in Leicester and Holden was estimated as high as 100 second feet per square mile, while in the lower section as low as 20 to 30 second feet per square mile. At Woonsocket the average peak run-off for the entire valley was 36 second feet per square mile.

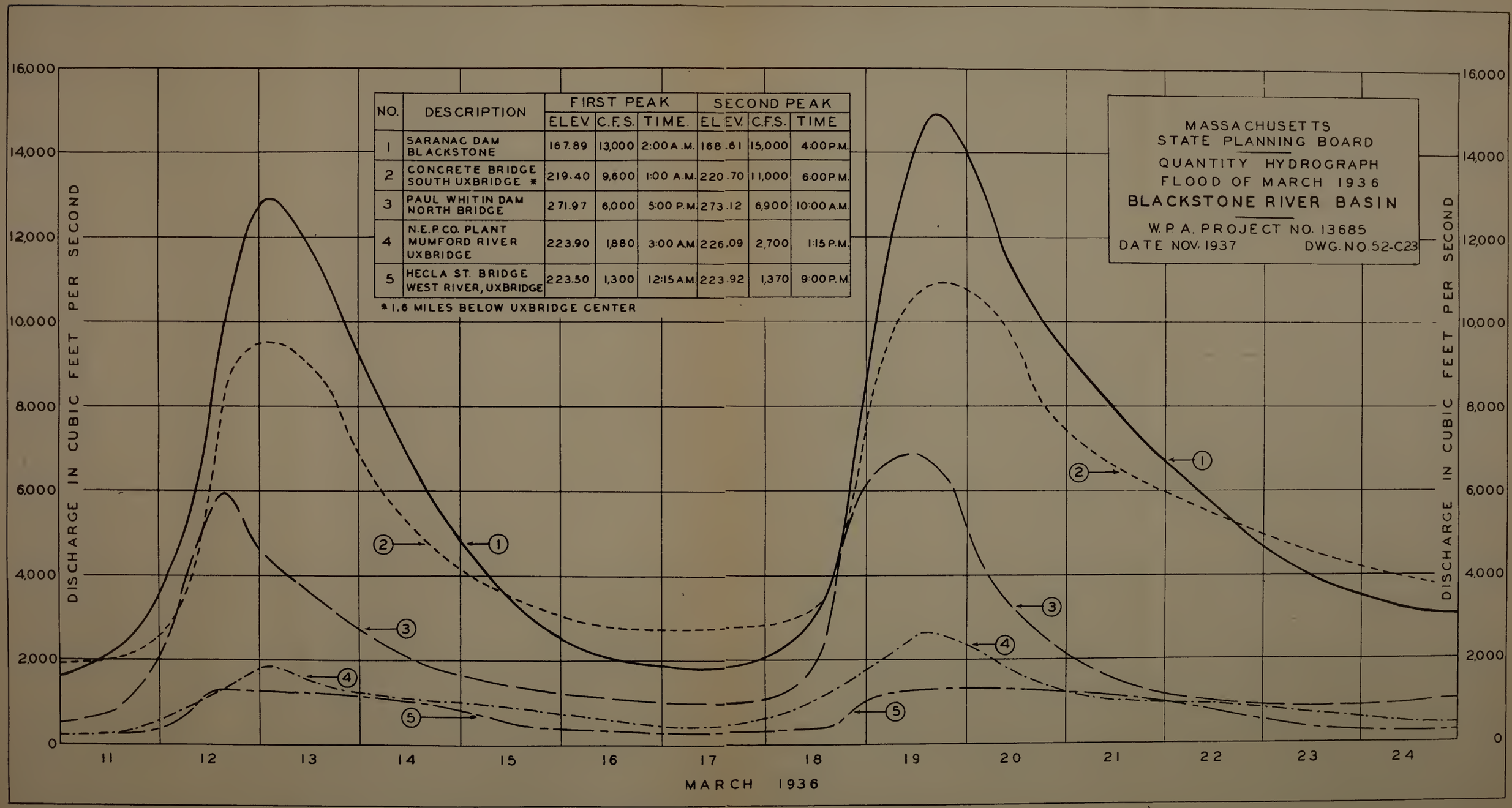
A large personnel was made available by the several Federal agencies during the flood, and very accurate and unusually comprehensive data relative to peak discharges and flood conditions were obtained. Some of the maximum discharges obtained at various points along the main river are listed in the following table:

Table 8

MAXIMUM FLOOD DISCHARGES - MARCH, 1936

| | | |
|---|---|---|
| Tatnuck Reservoir | 440 | c.f.s. |
| Kettle Brook Reservoir | 400 | " |
| American Steel & Wire Co. (South Works) | 3500 | " |
| Nortex Dam | 4200 | " |
| Fisher Mfg. Co. | 6700 | " |
| Paul Whitin Co. Dam | 6900 | " |
| Kupfer Bros. Dam | 7000 | " |
| Stanley Woolen (Rice City) (Uxbridge) | 7200 | " |
| Concrete Bridge (Millville) | 11500 | " |
| Blackstone Mfg. Co. Dam | 11700 | " |
| Woonsocket U.S.G.S. | 15000 | " |
| Mumford River (New England Power Co.) | 2700 | " |
| West River (Hecla Street Bridge) | 1370 | " |
| Quinsigamond River (Pleasant St. Grafton) | 1000 | " |

Damages for the Massachusetts portion of the Blackstone valley have been classified in the following table:




| NO. | DESCRIPTION | FIRST PEAK | | | SECOND PEAK | | |
|---|---|---|---|---|---|---|---|
| | | ELEV. | C.F.S. | TIME. | ELEV. | C.F.S. | TIME |
| 1 | SARANAC DAM BLACKSTONE | 167.89 | 13,000 | 2:00 A.M. | 168.61 | 15,000 | 4:00 P.M. |
| 2 | CONCRETE BRIDGE SOUTH UXBRIDGE * | 219.40 | 9,600 | 1:00 A.M. | 220.70 | 11,000 | 6:00 P.M. |
| 3 | PAUL WHITIN DAM NORTH BRIDGE | 271.97 | 6,000 | 5:00 P.M. | 273.12 | 6,900 | 10:00 A.M. |
| 4 | N.E.P.CO. PLANT MUMFORD RIVER UXBRIDGE | 223.90 | 1,880 | 3:00 A.M. | 226.09 | 2,700 | 1:15 P.M. |
| 5 | HECLA ST. BRIDGE WEST RIVER, UXBRIDGE | 223.50 | 1,300 | 12:15 A.M. | 223.92 | 1,370 | 9:00 P.M. |

* 1.6 MILES BELOW UXBRIDGE CENTER

Table 9

TYPES AND AMOUNT OF DIRECT DAMAGE
FLOOD OF MARCH, 1936

| | |
|---|---|
| Highways | $252,300 |
| Highway Bridges | 361,600 |
| Water Supply and Sewerage Systems | 53,300 |
| Other Municipal | 33,900 |
| Railroads | 31,853 |
| Other Utilities | 104,500 |
| Industrial and Commercial | 592,050 |
| Dams | 162,400 |
| Residential | 15,550 |
| Crop Lands | 1,700 |
| Total | 1,609,153 |

Detailed information on 1936 flood conditions is available in several special publications.

The information gathered during the recent flood on the Blackstone is of the utmost importance, but may be misleading unless all of the facts are considered. For instance, flood peaks caused by the topping of dams resulted in a great wash of water, which, together with heavy debris, lodged at the bridges and caused serious blockage and backwater conditions. The undue stress at these bridges caused many of them to be wrecked, highways to be washed out, cellars flooded, and merchandise stored on the lower floors of mills built close to the river to be destroyed. This, with the damage to power equipment, constituted flood losses which may be separately classified.

Many of the older dams, originally intended for power purposes, are now only used for the storage of process water, while others have been silted until little or no storage exists.

County authorities have complete jurisdiction over the inspection of these dams and, in view of the great damages of the recent flood, more rigid rules will undoubtedly prevail. No greater emphasis for this necessity can be given than the following extract from a field report:

> "In the March, 1936, flood there were 14 dams actually breached and three dams more or less damaged. There was one small solid concrete dam and three wooden dams among those washed out, but the majority were earth-fill with rubble walls. In practically all cases the spillways were inadequate to accommodate the flood and the dams were topped and breached."

Table 10

DAMAGED OR WRECKED DAMS - SEGREGATED BY TOWNS

| TOWN | DAMAGED | BREACHED | TYPE OF CONSTRUCTION |
|---|---|---|---|
| Boylston | | 1 | Earth-fill, rubble walls |
| Douglas | | 2 | Wood |
| Grafton | | 1 | Earth-fill, rubble walls |
| Leicester | 1 | 3 | Earth-fill, rubble or lll concrete walls |
| Millbury | | 1 | Rubble |
| Sutton | | 2 | Earth-fill, rubble walls |
| | | 1 | Ashlar face, rubble back |
| Upton | | 1 | Earth-fill, concrete walls |
| Uxbridge | 1 | 1 | Wood |
| | | | Earth-fill, rubble walls |
| Worcester | 1 | 1 | Earth-fill, rubble walls |
| | 3 | 14 | |

G. Frequencies

The Massachusetts State Planning Board has under preparation a report entitled "A Study of Magnitude and Frequency from Run-off Records of Floods in Massachusetts". The following paragraphs, which can be applied to the Blackstone River, have been extracted:

> "A study of floods and flood flows indicates that no recorded flood can be considered a maximum flood because sooner or later every so-called "greatest flood" is succeeded by one which attains a greater height, carries a greater volume, or is the cause of greater damage, than any flood which has gone before.
>
> "Continued and constantly increasing human occupancy of more or less frequently inundated areas, rather than the larger volume of flood run-off, is the principal cause for the ever-increasing damages.
>
> "Past experience and records demonstrate clearly that floods may be expected to occur at any time in any year, and that they often do occur several times in the same year.
>
> "Floods and combinations of floods are never repeated in nature, therefore, the happenings of one period of years cannot be accepted as an exact guide for future expectancies; but because there is no better method, past experience must be used in estimating probable flood frequencies".

Such frequency studies must be used carefully in order to avoid erroneous deductions. Various methods of estimating the magnitude and frequency of floods have been formulated by eminent hydraulic engineers. Among the formulae most accepted are those of Fuller, Hazen, Foster and Slade. Using these four methods and bearing in mind the limiting conditions of short records and imperfect data some idea of the magnitude and frequency of future flood flows may be obtained. No records of a greater flood than that of March,1936, are available.

The following flood frequency studies of gaging station No. 16 at Worcester, and gaging station No. 17 at Woonsocket, illustrate the application of these methods. The drainage area of gaging station No. 16 is 31.5 square miles. Table 11 presents for comparison the Fuller, Hazen, Foster and Slade calculations for the 1-20, 1-100, 1-1000 chance floods. It is interesting to note that the Fuller calculation for the 1-20 24-hour flood coincides exactly with the recorded 24-hour flow of the March, 1936, flood. Further, the Hazen and Foster results lead to the conclusion that an approximate 1,490 c.f.s. is a reasonable estimate for the maximum 1-20 flood.

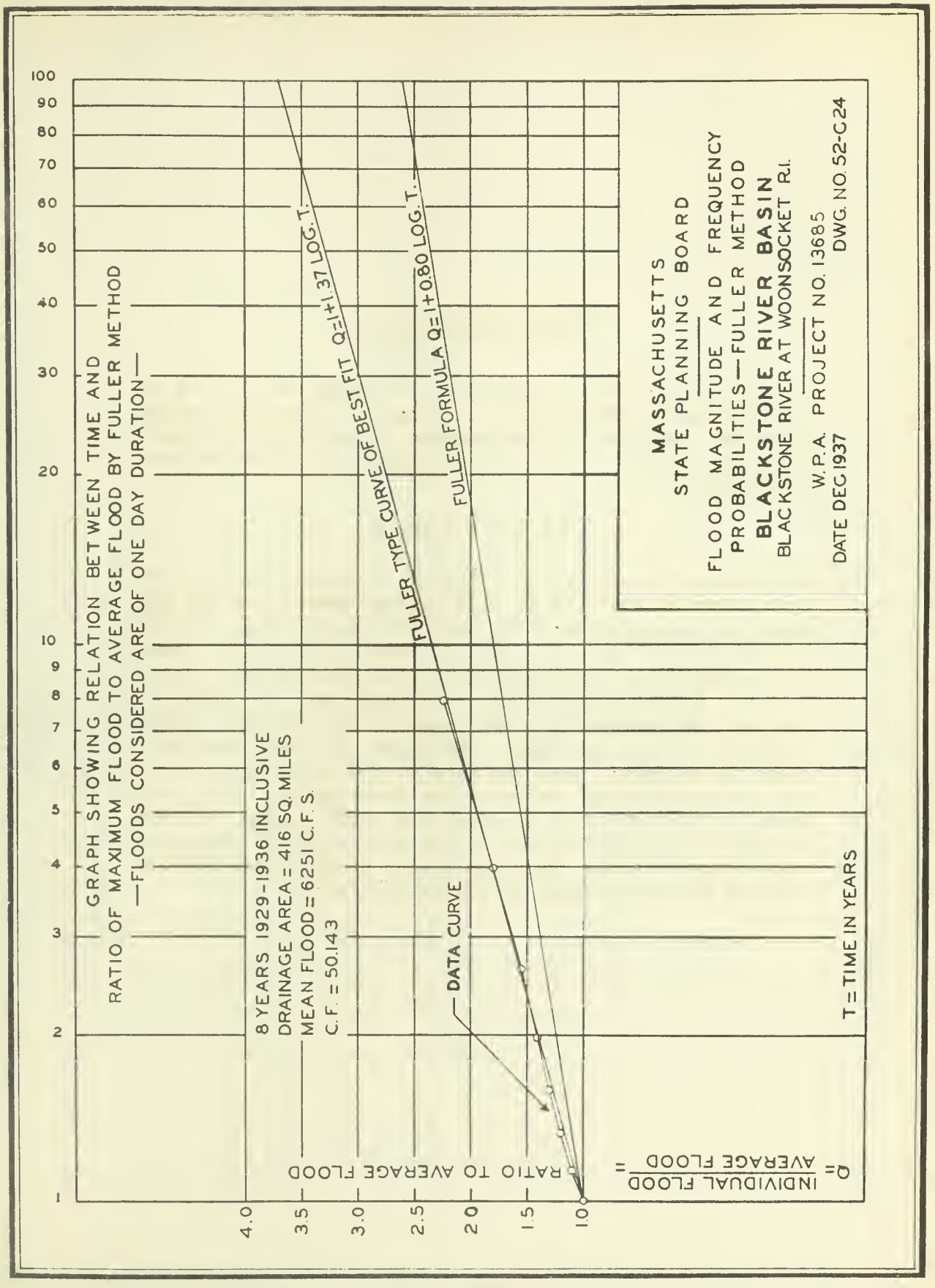
Very similar results were obtained in the calculation for gaging station No. 17 at Woonsocket, representing the entire Blackstone drainage area in Massachusetts. Here again Hazen and Foster methods were almost the same, and varied slightly from Fuller's. However, the peak recorded flow, 14,000 c.f.s., corresponded with the lower estimates of Hazen and Foster rather than with the higher estimates of Fuller. From these results it would seem that the 14,000 recorded flood was of the order of magnitude of a 1-20 chance flood.

We have noted in our study of "Magnitude and Frequency from Run-off Records of Floods in Massachusetts" that the Fuller values have a tendency to be high when computed for floods of fairly frequent recurrence.

Table 11

PER CENT CHANCE OF RECURRENCE
OF THE
MAXIMUM AVERAGE ANNUAL 24-HOUR FLOOD

| | 1 in 20 Volume in c.f.s. | 1 in 100 Volume in c.f.s. | 1 in 1000 Volume in c.f.s. |
|---|---|---|---|
| Fuller | 1,490 | 2,054 | 2,862 |
| Hazen | 1,184 | 2,189 | 4,462 |
| Foster | 1,158 | 1,849 | 2,941 |
| Slade | --- | 1,779 | 3,020 |
| Calculations for Worcester Station No. 16 - Drainage Area 31.5 sq. miles. Period of Record - 1923 to date | | | |
| Fuller | 17,390 | 23,379 | 31,943 |
| Hazen | 13,913 | 21,649 | 36,043 |
| Foster | 13,690 | 19,753 | 28,605 |
| Slade | --- | 19,455 | 29,795 |
| Calculations for Woonsocket Station No. 17 - Drainage Area 415 sq. miles. Period of Record - 1929 to date | | | |

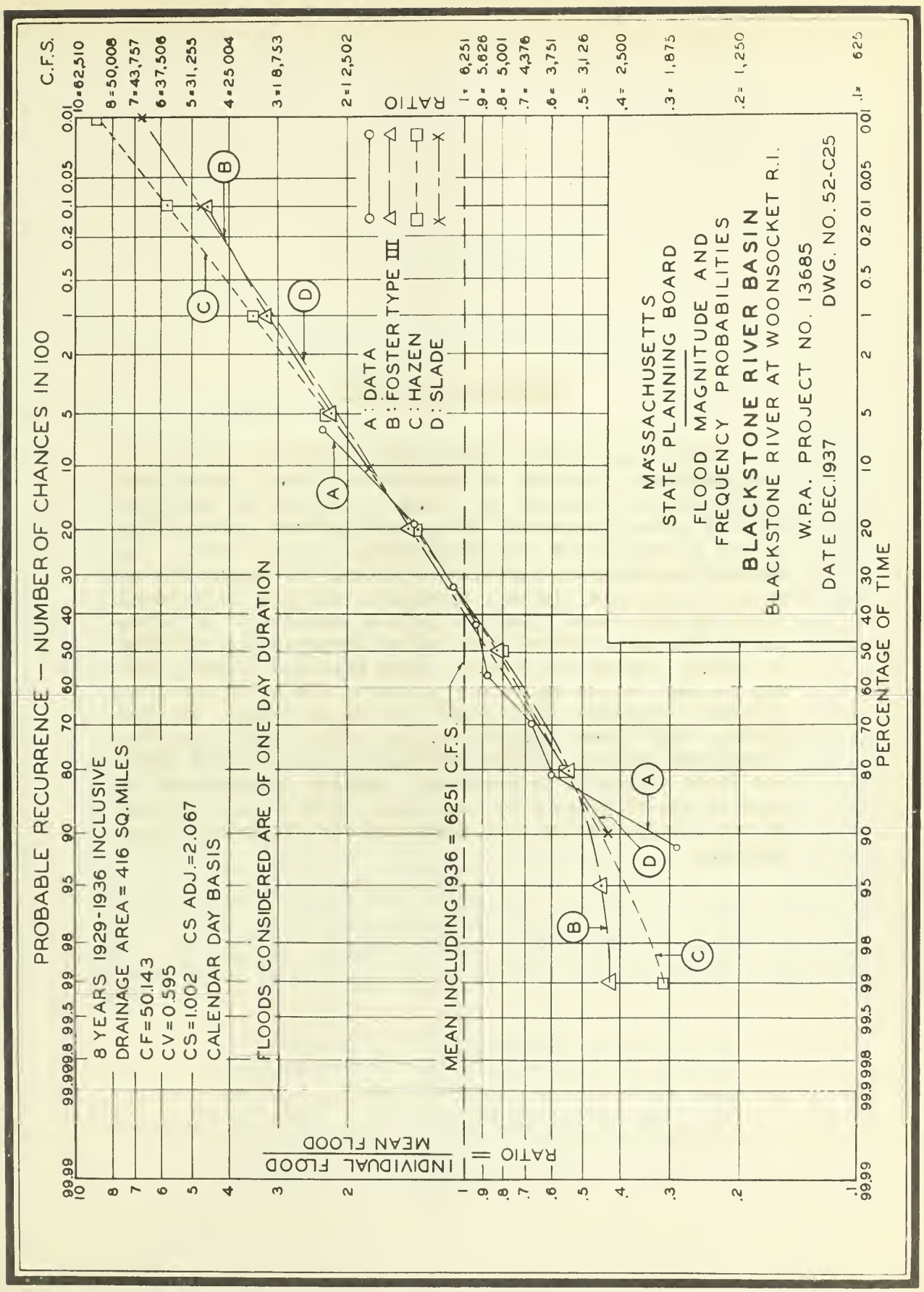

GRAPH SHOWING RELATION BETWEEN TIME AND
RATIO OF MAXIMUM FLOOD TO AVERAGE FLOOD BY FULLER METHOD
—FLOODS CONSIDERED ARE OF ONE DAY DURATION—
8 YEARS 1929-1936 INCLUSIVE
DRAINAGE AREA = 416 SQ. MILES
MEAN FLOOD = 6251 C.F.S.
C.F. = 50.143
FULLER TYPE CURVE OF BEST FIT Q=1+1.37 LOG. T.
FULLER FORMULA Q=1+0.80 LOG. T.
DATA CURVE
RATIO TO AVERAGE FLOOD
Q = INDIVIDUAL FLOOD / AVERAGE FLOOD
T = TIME IN YEARS
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
MASSACHUSETTS
STATE PLANNING BOARD
FLOOD MAGNITUDE AND FREQUENCY
PROBABILITIES—FULLER METHOD
BLACKSTONE RIVER BASIN
BLACKSTONE RIVER AT WOONSOCKET R.I.
W.P.A. PROJECT NO. 13685
DATE DEC 1937
DWG. NO. 52-C24

## EXPLANATION OF CHART

Chart No. 52-C24 shows the recorded data curve of the station at Woonsocket, R. I., and also the curves computed from the Fuller method. The Fuller formula curve is constant in all calculations and is plotted from the formula

$$Q = 1 + 0.8 \log T$$

in which Q = Quantity and T = Time in years. The Fuller type curve of best fit is the average moment of all the recorded data points. To read the charts find the desired ratio in the column at the left of the chart. Look to the right for the point of intersection of this ratio with the curve of best fit, and above will be found the per cent of chance of recurrence of this flood. Conversely, if the per cent of chance of recurrence of a flood is assumed, find the same at the top of the chart, and perpendicularly below at its intersection with the curve of best fit will be found the ratio (column at left of chart) which multiplied by the average flood will give the volume in cubic feet per second of the flood corresponding to the per cent of chance assumed.


PROBABLE RECURRENCE — NUMBER OF CHANCES IN 100
C.F.S.
8 YEARS 1929-1936 INCLUSIVE
DRAINAGE AREA = 416 SQ. MILES
CF = 50.143
CV = 0.595
CS = 1.002 CS ADJ. = 2.067
CALENDAR DAY BASIS
FLOODS CONSIDERED ARE OF ONE DAY DURATION
MEAN INCLUDING 1936 = 6251 C.F.S.
INDIVIDUAL FLOOD / MEAN FLOOD = RATIO
A: DATA
B: FOSTER TYPE III
C: HAZEN
D: SLADE
RATIO
PERCENTAGE OF TIME
MASSACHUSETTS
STATE PLANNING BOARD
FLOOD MAGNITUDE AND
FREQUENCY PROBABILITIES
BLACKSTONE RIVER BASIN
BLACKSTONE RIVER AT WOONSOCKET R.I.
W.P.A. PROJECT NO. 13685
DATE DEC. 1937
DWG. NO. 52-C25

## EXPLANATION OF CHART

Chart No. 52-C25 presents flood frequency curves for the Woonsocket station of Blackstone River, based upon maximum annual calendar day flow. The curve of recorded data is shown together with extrapolated probability curves of recurrence and magnitude of future floods, as derived according to formulae of Hazen, of Foster and of Slade. The data curve represents ratio of individual flood to mean flood plotted against percentage of time. The curves were plotted from tables computed and published by Hazen, Foster and Slade. They are skew curves, and may be read in the following manner: To ascertain the probable frequency of a flood of the magnitude of the March, 1936 flood (14,000 c.f.s.) find 14,000 in the right-hand column; follow horizontal line to left until the Hazen curve is intersected, reading percentage of time at top of graph - in this case 5%, or 1 in 20 chance of recurrence. Follow same procedure for Foster and Slade methods.

## CHAPTER IV

## EXISTING CONDITIONS AND ADEQUACY

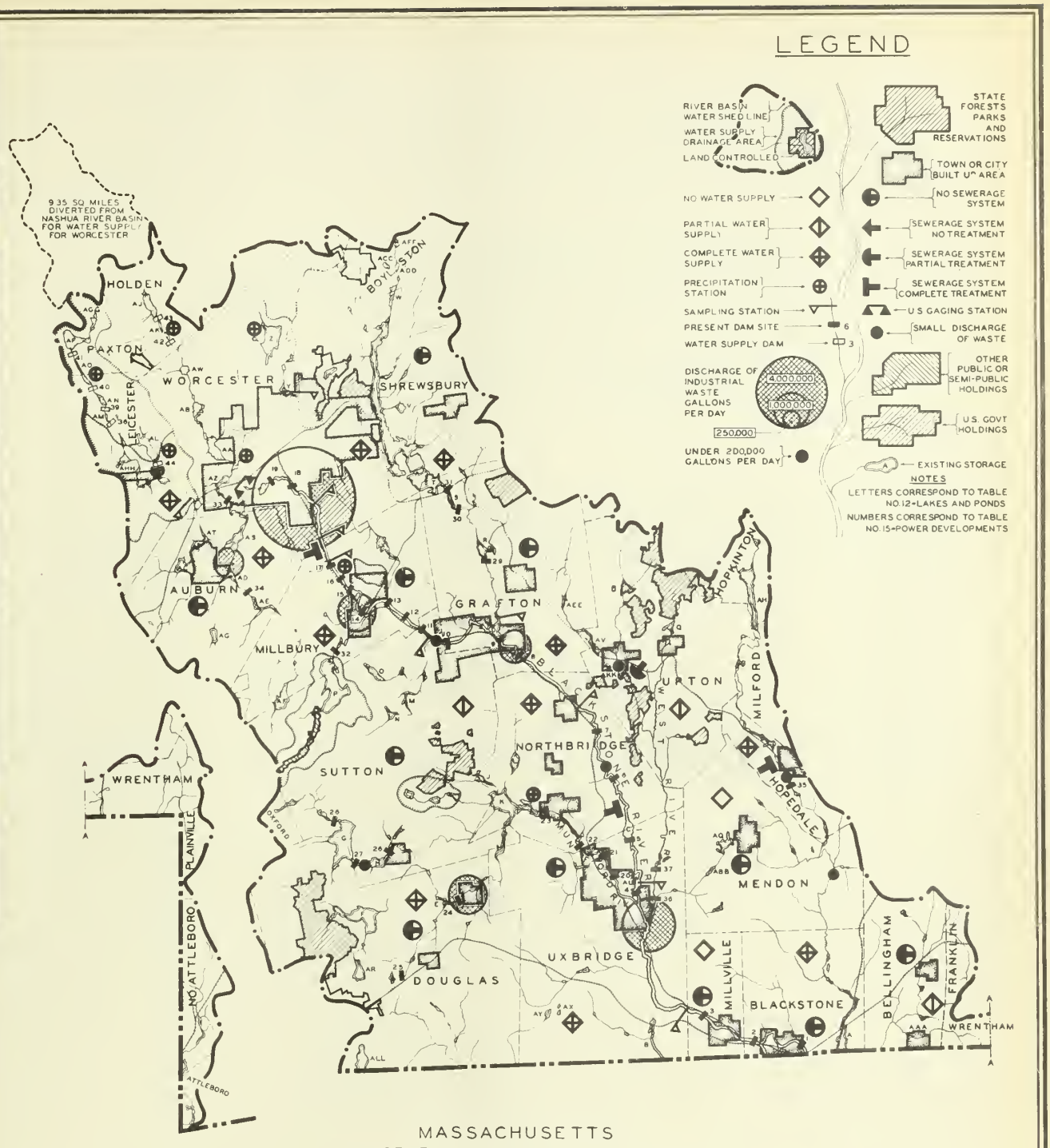
### A. Flow Control

The first storage created on the river was for the benefit of the Blackstone Canal. Chapter 27 of the Acts of 1822, which incorporated the canal, gave it the right to raise and use Lake Quinsigamond, Dorothy Pond and North Pond for storing water for canal purposes. With the abandonment of the canal these rights were sold. Between 1820 and 1870 natural ponds were raised and artificial reservoirs created by an association of mills. Among these were Willis Pond Reservoir, Manchaug Pond on Mumford River, Singletary Pond on Singletary Brook, Clark and Sibley Reservoirs on Cold Spring Brook, and reservoirs on Kettle Brook above Worcester.

Storage has since been highly developed both for power and process water for manufacturing purposes. On the small streams which merge in the southwestern part of Worcester to form the main river, covering a total drainage area of about 60 square miles, the flow of Tatnuck, Lynde and Kettle Brooks is regulated by reservoirs for the water supply of the city of Worcester, and the flow of the remainder of the streams within the area is controlled by the dams of the American Steel & Wire Company, and the Worcester Electric Light Company, both of which require large amounts of water. Complete regulation already exists on Mill Brook Channel (drainage area 13 square miles) controlled by the American Steel & Wire Company.

> "The mills are intimately interested in absolute control and conservation as evinced by the many reservoirs created by them and the raising of the natural ponds, and they undoubtedly will continue improvements when industrial conditions warrant and financial benefits are assured."*

*U.S. Engineer Report 1929




MASSACHUSETTS
STATE PLANNING BOARD

# BLACKSTONE RIVER WATER RESOURCES DATA

WPA PROJECT NO 13685

SCALE IN MILES
1 0 1 2 3 4 5 6 7

DECEMBER 1937

72-23-8

1. Flood Control

A United States Engineer Report dated April, 1929, reads in part:

> "In view of the condition that storage is already highly developed and that the use of a considerable portion of the waters of Branch River, the largest tributary, for the water supplies in Rhode Island has recently been suggested by a State Commission, (Now built) there appears to be no public necessity for flood-control works."

Since the date of this report, however, the March, 1936, flood occurred, and many defective dams have been washed out or breached, channels have become clogged, and many reservoirs and ponds have silted.

a. Reservoirs and Detention Basins

The high development of storage is shown in the following table:

Table 12

EXISTING STORAGE
PRINCIPAL LAKES AND PONDS ON THE BLACKSTONE RIVER IN MASSACHUSETTS

| NO. | NAME OF POND | TOWN | FLOW REGULATED BY | DRAINAGE AREA (SQ.MI.) | AREA OF POND (ACRES) | DRAFT (FEET) | ESTIMATED STORAGE (MILLION CUBIC FEET) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| A. | Harris Pond | Blackstone | Woonsocket Rayon Co. | 34.5 | 135 | 12 | | Partly in R. I. |
| B. | Ironstone Reservoir | Uxbridge | Rhode Island Ice Co. | 4.9 | 86 | 12 | | 48 acres in R. I. 38 acres in Mass. |
| C. | Rice City Pond | Uxbridge | Stanley Woolen Co. | 147. | 154 | | 43.6 | |
| D. | Fisherville Pond | Grafton | Fisher Mfg. Co. | 97.4 | 98 | 11 | | |
| E. | Laurel Lake | Douglas | Schuster Woolen Co. | 1.0 | 67 | 3.5 | 10.0 | Raised natural pond. |
| F. | Willis Pond Reservoir | Douglas | Whitin Machine Works | 8.9 | 250 | 22.0 | 180.0 | Artificial reservoir Dam 500 ft. long, 30 ft. maximum height. |
| G. | Manchaug Pond | Douglas & Sutton | Whitin Machine Works | 6.7 | 360 | 15.0 | 191.0 | Raised pond; dam 19 ft. maximum height. |
| H. | Stevens Pond | Sutton | Whitin Machine Works | 16.0 | 75 | 15 | | Artificial mill pond. |

EXISTING STORAGE
PRINCIPAL LAKES AND PONDS ON THE BLACKSTONE RIVER IN MASSACHUSETTS
(Cont'd.)

| NO. | NAME OF POND | TOWN | FLOW REGULATED BY | DRAINAGE AREA (SQ.MI.) | AREA OF POND (ACRES) | DRAFT (FEET) | | REMARKS |
|---|---|---|---|---|---|---|---|---|
| J. | Swans Pond | Sutton & Northbridge | Whitin Machine Works | 3.6 | 26 | 8 | | Dam destroyed. |
| K. | Whitins Pond | Uxbridge, Sutton & Northbridge | Whitin Machine Works | 49.0 | 350 | 4.0 | 61.0 | Artificial mill pond. |
| L. | Carpenters Pond | Northbridge | Whitin Machine Works | | 97 | 25 | | Average depth 30' |
| M. | Pleasantdale Pond | Sutton | Taylor Apple Stor.&Millers Ice Co. | 3.6 | 26 | | | Artificial mill pond Dam breached. |
| N. | Clarks Reservoir | Sutton | Dudley Spindle Shop | 2.6 | 40 | 16.0 | 14.0 | Artificial reservoir Dam destroyed. |
| O. | Sibley Reservoir | Sutton | Sibley Reservoir Co. | .5 | 55 | 12.0 | 20.0 | Artificial reservoir Dam 21 ft. maximum height. |
| P. | Singletary Pond | Sutton & Millbury | Mills on Singletary Brook | 4.2 | 356 | 7.0 | 103.0 | Raised natural pond. |
| Q. | Pratt Pond | Upton | L.A.Snow | 2.1 | 22 | 5.0 | 4.0 | |
| R. | Goddard Pond | Grafton | Grafton Bleach & Dye Co. | 36.6 | 76 | 6.0 | | Mill Pond; mill not in operation. |

EXISTING STORAGE
PRINCIPAL LAKES AND PONDS ON THE BLACKSTONE RIVER IN MASSACHUSETTS
(Cont'd.)

| NO. | NAME OF POND | TOWN | FLOW REGULATED BY | DRAINAGE AREA (SQ.MI.) | AREA OF POND (ACRES) | DRAFT (FEET) | ESTIMATED STORAGE (MILLION CUBIC FEET) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| S. | Hovey Pond | Grafton | The Linen Thread Co. | 26.3 | 68) | | | Hovey Pond, Flints Pond&Lake Quinsigamond, essentially one body of water, covering 929 acres, |
| T. | Flints Pond | Grafton, Shrewsbury & Worcester | The Linen Thread Co. | 26.1 | 322) | 6.5 | 225.0 | |
| U. | Lake Quinsigamond | Shrewsbury & Worcester | The Linen Thread Co. | 25.7 | 539) | | | and controlled by dam at foot of Hovey Pond in North Grafton. |
| V. | Jordan Pond | Shrewsbury | Walker Ice Co. | .6 | 27 | | | |
| W. | Newton Pond | Shrewsbury & Boylston | Lincoln Sand & Gravel Co. | 4.1 | 35 | | | Dam destroyed. |
| X. | Dorothy Pond | Millbury | Buck Brothers | 4.5 | 75 | 9.0 | 22.0 | Raised natural pond Dam, lift, maximum height. |
| Y. | Salisbury Pond | Worcester | American Steel & Wire Co. | 7.8 | 25 | | 7.0 | Artificial mill Pond. |
| Z. | North Pond | Worcester | American Steel & Wire Co. | 3.9 | 186 | 4.0 | 30.0 | Natural pond, raised 8 ft. |

EXISTING STORAGE
PRINCIPAL LAKES AND PONDS ON THE BLACKSTONE RIVER IN MASSACHUSETTS
(Cont'd.)

| NO. | NAME OF POND | TOWN | FLOW REGULATED BY | DRAINAGE AREA (SQ. MI.) | AREA OF POND (ACRES) | DRAFT (FEET) | ESTIMATED STORAGE (MILLION CUBIC FEET) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| AA. | Coes Reservoir | Worcester | Loring Coes | 10.4 | 119 | | | Artificial mill pond; large part of drainage area diverted. |
| AB. | Patches Pond | Worcester | Independent Ice Co. | 6.1 | 45 | | | |
| AC. | Stoneville Reservoir | Auburn | Auburn Textile Co. | 5.8 | 92 | 11.0 | 21.0 | Earth dam, 21 ft. maximum height; artificial reservoir. |
| AD. | Dunns Pond | Auburn | American Steel Wire Co. | 11.3 | 26 | | | Formerly mill pond for shoddy mill. |
| AE. | Pondville Pond | Auburn | Pondville Woolen Co. | 7.7 | 50 | | | Mill pond. |
| AF. | Ramshorn Pond | Sutton & Millbury | American Steel & Wire Co. | 2.3 | 99 | 12.0 | 29.0 | Raised natural pond. |
| AG. | Eddy Pond | Auburn | American Steel & Wire Co. | 1.1 | 35 | | | Low earth dam, 3 to 4 feet high. |
| AH. | North Pond | Hopkinton & Milford | Mills on Mill River | 3.1 | 234 | 12.0 | 75.0 | |

EXISTING STORAGE
PRINCIPAL LAKES AND PONDS ON THE BLACKSTONE RIVER IN MASSACHUSETTS
(Cont'd.)

| NO. | NAME OF POND | TOWN | FLOW REGULATED BY | DRAINAGE AREA (SQ. MI.) | AREA OF POND (ACRES) | DRAFT (FEET) | ESTIMATED STORAGE (MILLION CUBIC FEET) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| AJ. | Holden Reservoir No.1 | Holden | City of Worcester | | 130 | | 97.5 | Worcester Water Supply |
| AK. | Holden Reservoir No. 2 | Holden | City of Worcester | 5.2 | 53 | | 34.4 | Worcester Water Supply. |
| AL. | Lynde Brook Reservoir | Leicester | City of Worcester | 2.9 | 132 | | 93.5 | Worcester Water Supply. |
| AM. | Kettle Brook Reservoir No. 1 | Leicester | City of Worcester | 5 | 5 | | 2.6 | Worcester Water Supply. |
| AN. | Kettle Brook Reservoir No. 2 | Leicester | City of Worcester | 2.3 | 31 | | 17.3 | Worcester Water Supply. |
| AO. | Kettle Brook Reservoir No. 3 | Leicester & Paxton | City of Worcester | 1.6 | 37 | | 20.4 | Worcester Water Supply. |
| AP. | Kettle Brook Reservoir No. 4 | Paxton | City of Worcester | .9 | 119 | | 68.7 | Worcester Water Supply |
| AQ. | Nipmuck Pond | Mendon | | .8 | 66 | | | |
| AR. | Bad Luck Pond | Douglas | Charles Ch. Sawmill | | 67 | | | |
| AS. | Leesville Pond | Auburn | American Steel&Wire Co. Rendering Co. | 27.1 | 70 | 6 | 12.2 | |
| AT. | Auburn Textile | Auburn | American Steel&Wire Co. Rendering Co. | No Information Available | | | | |
| AU. | Hecla Pond | Uxbridge | Tanning Co. (Out of business) | | 45 | | | Dam destroyed. |
| AV. | Jourdans Pond | Upton | Town | | | | | |

EXISTING STORAGE
PRINCIPAL LAKES AND PONDS ON THE BLACKSTONE RIVER IN MASSACHUSETTS
(Cont'd)

| NO. | NAME OF POND | TOWN | FLOW REGULATED BY | DRAINAGE AREA (SQ.MI.) | AREA OF POND (ACRES) | DRAFT (FEET) | ESTIMATED STORAGE (MILLION CUBIC FEET) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| AW. | Cooks Pond | Worcester | Tatnuck Fish & Game Society | 7.5 | 15 | 15 | 6.5 | |
| AX. | Black Pond | Uxbridge | | | 1 | | | |
| AY. | Chockalog Pond | Uxbridge | Town & Ice Co. | | 15 | | | |
| AZ. | Curtis Pond | Worcester | Worcester Elec. Light Co. | 31.3 | 32 | 10 | 8.424 | |
| AAA. | Jenks Reservoir | Bellingham | Town | | 7 | | | |
| ABB. | Little Pond | Mendon | Jack Hogarth | | 18 | | | |
| ACC. | Pout Pond | Boylston (Mud Flats) | Town Assessors | | 8 | | | |
| ADD. | Sewall Pond | Boylston | Dakins Fish Co. | | 8 | | | |
| AEE. | Silver Lake | Grafton | Boat House-Grafton Co. & Ice Co. | | 18 | | | |
| AFF. | Spruce Pond (Rocky Pond) | Boylston | Town Assessors | | 8 | | | |
| AGG. | Upper Reservoir | Paxton | | 1.6 | 20 | | | |
| AHH. | Waite Pond | Leicester | Peter Brook Woolen Mills | | 50 | | | |
| ALL. | Wallum Pond | Douglas | R.I.Ice Co.(Burnt down) | | 145 | | | |
| AKK. | Zackery Pond (Old Zack) | Upton | Paper Box Co. (Out of business) (Town) | | 5 | | | |

b. Channel Conditions

In 1935 an Emergency Relief Administration project survey was made of channel conditions. This survey resulted in detailed recommendations for the removal of heavy vegetation and debris, the elimination of abrupt turns, channel widening and deepening, etc. Maps* of the river showing location of bridges, dams, highways, railways, and other important data were prepared. The following table was compiled, which shows the present channel capacities at points between the Rhode Island-Massachusetts state line and the town of Uxbridge:

Table 13

ESTIMATED CAPACITIES OF PRESENT CHANNEL
AT REPRESENTATIVE POINTS

| Station | Capacity c.f.s. | Station | Capacity c.f.s. | Station | Capacity c.f.s. |
|---|---|---|---|---|---|
| 3 | 6,600 | 147 | 13,300 | 200 | 20,000 |
| 12 | 11,200 | 149 | 8,500 | 207 | 13,300 |
| 28 | 17,000 | 151 + 50 | 10,600 | 223 | 7,000 |
| 44 | 15,500 | 160 | 14,400 | 248 | 3,800 |
| 46 | 21,000 | 164 | 8,000 | 295 | 3,500 |
| 126 | 12,000 | 166 | 9,500 | 330 | 4,100 |
| 131 | 4,800 | 170 | 9,800 | 361 | 2,000 |
| 133 | 6,500 | 180 | 9,200 | 373 | 3,000 |
| 140 | 8,500 | 190 | 7,700 | 391 | 3,700 |

Station 0 + 00 is at the State line. Stations recur at 100 ft. intervals to Station 393 + 00 which is located in Uxbridge at the N.Y. N.H.& H. Railroad bridge.

From the results of this survey estimates of costs were compiled and presented to the Works Progress Administration at Washington, which resulted in a conditional Federal allotment of $430,710. Among the conditions were provisions that the various towns must provide all the necessary easements, acquire any necessary property,and be responsible for any local or other damages resulting from any of the improvements.

*For list of channel improvement maps see appendix E. These maps are on file with the Massachusetts State Planning Board.

65-14-3101 Allotment - $129,695

UXBRIDGE

Flood control of the Blackstone River between the N.Y.N.H. & H.R.R. bridge and Mendon Street.

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65-14-3102 Allotment - $176,778

UXBRIDGE

Flood control of the Blackstone River between the N.Y.N.H. & H.R.R. bridge and Millville town line.

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65-14-3100 Allotment - $ 11,449

MILLVILLE

Flood control of the Blackstone River, town of Millville.

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65-14-3127 Allotment - $ 78,629

BLACKSTONE

Flood control of the Blackstone River in the Mill Pond section of the town by general improvement of the river channel. Excavation of earth.

---

65-14-3126 Allotment - $ 34,159

BLACKSTONE

"Flood control on the Blackstone River in non-navigable streams and general improvements of the channel, including cleaning, and excavating of earth, starts at the Rhode Island-Massachusetts line at the city of Woonsocket, and extends in a northwesterly direction some 2,900 feet. To be distinguished from O.P. 65-14-3127 which starts 1,400 feet upstream from the Blackstone Manufacturing Co. dam, which is 275 feet from the Rhode Island-Massachusetts line at the town of North Smithfield, and extends approximately 1,00( feet. A river distance of approximately 1 mile separates the two projects."

---

TOTALS - $430,710

An Act* creating the Blackstone River Valley District and defining its powers and duties was enacted by the Massachusetts General Court on April 30, 1936, and revised on June 24, 1936, by Chapter 410. A similar Act was approved on May 2 by the State of Rhode Island.

> "To provide for the establishment of a Board to act jointly with the Massachusetts authorities as an authority to be known as the Blackstone Valley Authority."

In Massachusetts 17 municipalities were to be represented on the Board, including the city of Worcester. Several meetings were held, but no definite results were obtained. About six towns were willing to comply with all of the conditions of the Federal allotment and provisions of the State Act; the others held back for varying reasons, among which were the stumbling blocks of securing easements and fear of resulting damage suits. No joint action with the Rhode Island Board was therefore possible, and the Federal allotment never became effective.

A recent inspection of the river (April, 1937) shows channel conditions as follows:

"Beginning at the dam of the American Steel & Wire Company at the southerly part of the city of Worcester the channel condition below the dam is unnecessarily bad; the river bed is more or less choked with debris, and the alignment of the stream is such that any material increase in the flow will cause overflowing of the banks and consequent damage to surrounding property. This condition, especially through the property owned by the American Steel & Wire Company for a distance of more than a mile below this dam, has been gradually aggravated by the dumping of mill refuse along the banks, causing barriers which have seriously affected both the alignment and flowage capacity of the river.

"The tributaries above this portion of the river drain an area of approximately 50 square miles. The topography of the upper region is such that the run-off is quick and any decided increase in rainfall causes sudden and appreciable rises in stage height.

"As the river flows from the city of Worcester into the town of Millbury it passes under a bridge at McCracken Road. This is a two-arch concrete bridge with an effective waterways for normal flow but is inadequate to pass any considerable increase of river flow. During the flood of March, 1936, this bridge was completely submerged. There is evidence of some erosion, particularly below the Millbury Woolen Company's dam, caused by bad alignment of the channel,and also due in large measure to stream blockage from the dumping of refuse.

*See Appendix A

"Below the Millbury Woolen Company the next point of observation was the Anco Mills in the town of Sutton. Above the Anco dam the pond appears to be very badly silted, forming a marshy island of probably three or four acres in extent. Below the dam the river is badly choked both by accumulated debris and vegetable growth of brush and overhanging trees. This condition exists from the Anco dam downstream to the Anco Mills, where there are the remains of an old dam which should be removed.

"Passing down the river through the towns of Grafton, Northbridge and Uxbridge, there are the following dams:

| | |
|---|---|
| Fisher Manufacturing Co. | - Grafton |
| Paul Whitin Co. | - Northbridge |
| Kupfer Bros. | - Northbridge |
| Stanley Woolen Co. | - Uxbridge |
| Millville U.S. Rubber | - Uxbridge |

"At each of the above locations practically the same conditions exist, namely, silting above the dams causing restricted pondage and consequent wide overflowing with a rise of water level, and in every case bad alignment, with obstructions choking the channel below the dam.

"From the observations taken at this time it is very evident that a large part of the damage caused by last year's flood was aggravated by the obstructions in the river, the neglect of the owners to keep the channel below the dam clear, and the accumulation of silt that had deposited above the dams. This reduced pondage caused widespread overflowing.

"There are several bridges where the openings are not sufficient to pass more than a slight increase above the normal flow of the river."

c. Structures Subject to Inundation

Mills of necessity have been built close to the stream, hence the lower floors are subject to inundation by extreme high water. Stocks and power equipment have shown high loss during extreme floods, but, as already pointed out, damage has been aggravated by the failure of dams and conditions which result from such a disaster, more often than from typical freshet flows.

The structures subject to flooding along the Blackstone, tabulated by types of buildings, follows:

Table 14

TYPES OF BUILDINGS INUNDATED - FLOOD MARCH, 1936

PUBLIC BUILDINGS

| | |
|---|---|
| Blackstone | 2 |
| Worcester | 17 |
| Total | 19 |

INDUSTRIAL BUILDINGS

| | |
|---|---|
| Worcester | 27 |
| Grafton | 1 |
| Millbury | 4 |
| Northbridge | 4 |
| Sutton | 1 |
| Uxbridge | 2 |
| Total | 39 |

HOUSES

| | |
|---|---|
| Blackstone | 47 |
| Douglas | 7 |
| Grafton | 9 |
| Millville | 10 |
| Northbridge | 40 |
| Upton | 3 |
| Uxbridge | 40 |
| Worcester | 20 |
| Millbury | 3 |
| Total | 179 |

For an analysis of the above table turn to Appendix C.

d. Dikes

There are no dikes along the river.

e. Erosion

During the 1936 flood stream banks showed very little damage except at bridge approaches. Planting or revetment work will help prevent washouts. This type of work can usually be considered as part of highway or bridge construction. Some general erosion, however, was noted, totaling about 21.53 acres, which included scouring away part of the banks, listed as follows:

| | |
|---|---|
| Northbridge | 9.87 acres |
| Millville | 2.02 " |
| Upton | 9.64 " |
| Total | 21.53 acres |

Table 15

MASSACHUSETTS WATER POWER DEVELOPMENTS

BLACKSTONE RIVER BASIN

| NO. | TOWN | NAME OF PLANT | NAME OF OWNER | HEAD FEET | DRAINAGE AREA SQ. MI. | THEORETICAL H.P. 60% OF TIME | PRESENT INSTALLED H.P. | DEVELOPED H.P. | UNDEVELOPED H.P. | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | BLACKSTONE RIVER | | | | | | | |
| 1. | Blackstone | Saranac Mills | Joseph E. Kelly<br>Joseph E. LeFrancois<br>Arthur I. Darmon | 10 | 363 | 410 | 400 | 400 | | |
| 2. | No.Smithfield, R.I. | Blackstone Mfg. Co. | Blackstone Mfg. Co. | 31 | 260 | 920 | 1500 | 1500 | | |
| 3. | Millville | U.S. Rubber Co. | Lawrence Felting Co. | 12 | 258 | 380 | 450 | 450 | | Mills idle, equipment in fair condition. Dams wrecked. |
| 4. | Uxbridge | Hecla Mills | J. B. Groosman | 9 | 147 | 135 | 190 | 190 | | " " " " |
| 5. | Uxbridge | Stanley Woolen Co. | Stanley Wheelock | 12 | 146 | 200 | 230 | 230 | | - |
| 6. | Northbridge | Kupfer Bros. Co. | Kupfer Bros. Co. | 8 | 141 | 160 | 350 | 350 | | - |
| 7. | Northbridge | Rockdale Mills | Paul Whitin Mfg. Co. | 12 | 139 | 160 | 300 | 300 | | - |
| 8. | Grafton | Waskanut Mills | Waskanut Mills, Inc. | 7.5 | 135 | 110 | 180 | 180 | | - |
| 9. | Grafton | Fisherville Mills | Fisher Mfg. Co. | 11 | 134 | 150 | 390 | 390 | | - |
| 10. | Grafton | Saunders Cotton | Saunders Cotton Mills | 12 | 93 | 130 | 400 | 400 | | Hydraulic equipment beyond repair. Mill partially used. |
| 11. | Sutton | Anco Mills | W. A. Green Apple Storage | 21 | 85 | 200 | 400 | 400 | | Mills idle. Hydraulic equipment in good condition. |
| 12. | Millbury | N.E.P. Co. | N.E.P. Co. | 14 | 83 | 130 | - | - | x | - |
| 13. | Millbury | Millbury Woolen Co. | Heywood Schuster Co. | 8 | 77 | 120 | 150 | 150 | | Only about 40 H.P. used. |
| 14. | Millbury | Nortex Mill | Nat'l Crash Mfg. Co. | 13 | 77 | 110 | 160 | 160 | | Mill idle. Hydraulic equipment beyond repair. Dam |
| 15. | Millbury | Atlanta Woolen Co. | Atlanta Woolen Co. | 10 | 77 | 90 | - | - | x | wrecked. This fall could be combined with the Nortex Fall, #14 in this table. |
| 16. | Millbury | Felters Co. | Felters Co. | 8 | 71 | 65 | - | - | x | - |
| 17. | Millbury | S. E. Hull Co. | S. E. Hull Co. | 16 | 65 | 115 | - | - | x | - |
| 18. | Worcester | A.S. & W. Co. (South Works) | Am. Steel & Wire Co. (South Works) | 14 | 50 | 75 | 25 | 25 | | Water used for process. |
| 19. | Worcester | M.J. Whittall | M.J. Whittal, Asso.Ltd. | 10 | - | - | - | - | | - |

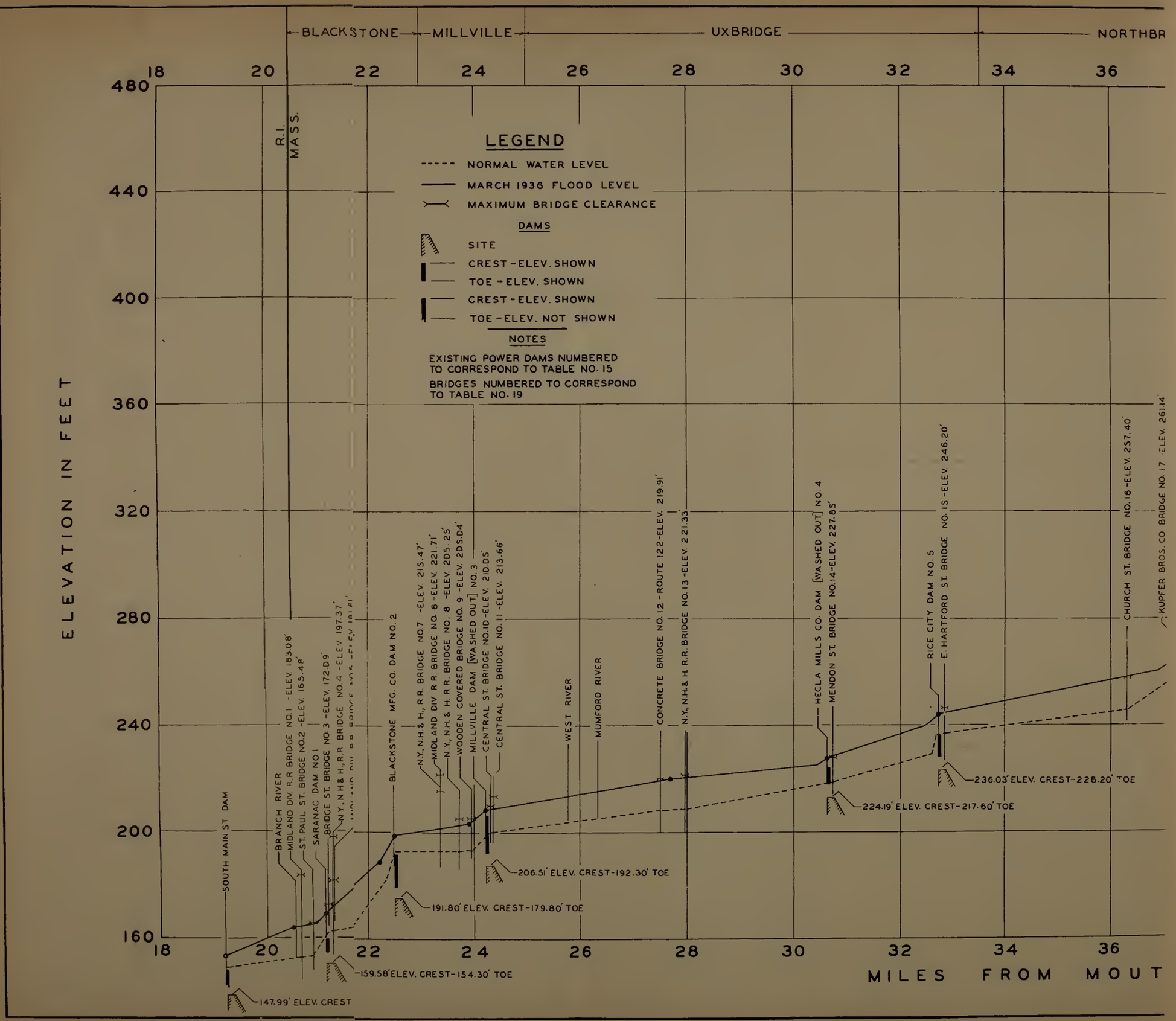
Table 15

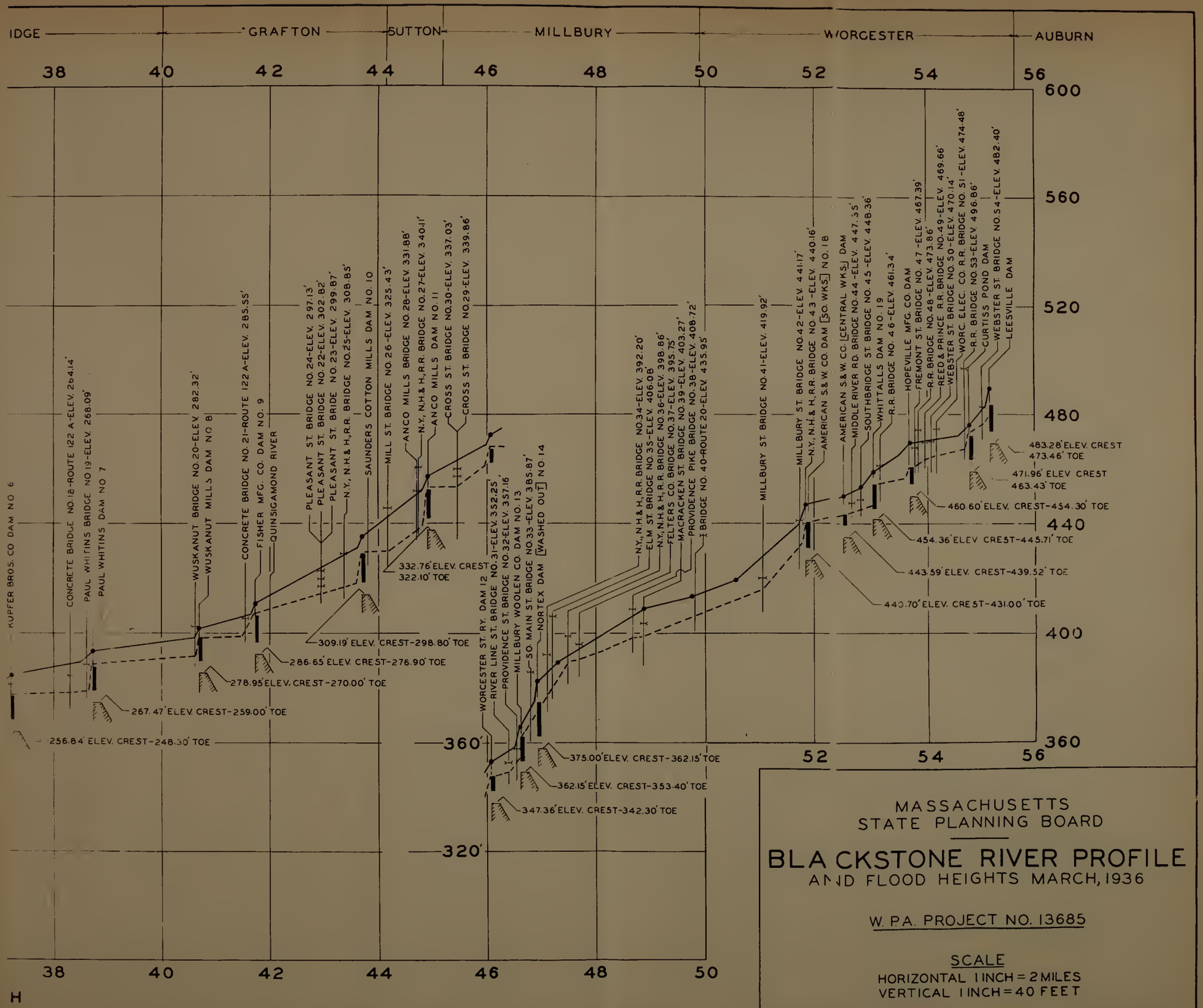
MASSACHUSETTS WATER POWER DEVELOPMENTS

BLACKSTONE RIVER BASIN
(Cont'd)

| NO. | TOWN | NAME OF PLANT | NAME OF OWNER | HEAD FEET | DRAINAGE AREA SQ. MI. | THECRETICAL H.P. 60% OF TIME | PRESENT INSTALLED H.P. | DEVELOPED H.P. | UNDEVELOPED H.P. | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MUMFORD RIVER | | | | | | |
| 20. | Uxbridge | Root Mills | Uxbridge Worsted Co. Inc. | 13 | 58 | 85 | 135 | 135 | | - |
| 21. | Uxbridge | Whitin Mills | J.E.Whitin Co. | 18 | 52 | 95 | 340 | 340 | | - |
| 22. | Northbridge | Mill No. 1. | Whitin Bros. | 17 | 51 | 70 | 270 | 270 | | - |
| 23. | Northbridge | Whitin Mach.Co. | Whitin Mach. Co. | 18 | 49 | 210 | 375 | 375 | | Two falls. |
| 24. | Douglas | Schuster Mills | Schuster Woolen Co. | 10 | 28 | 85 | 120 | 120 | | Two falls. |
| 25. | Douglas | Heywood Mills | Heywood Woolen Co. | 10-12 | 26 | 65 | 250 | 250 | | Two falls. |
| 26. | Sutton | Cohen Mill | Cohen Mill | 20 | 21 | 50 | 300 | | 300 | Hydraulic equipment. beyond repair. |
| 27. | Sutton | Stevens Mill | Stevens Mill | 20 | 21 | 50 | 300 | | 300 | " " |
| 28. | Sutton | Salisbury Mills | Schuster Woolen Co. | 34 | - | - | - | x | | - |
| | | | | QUINSIGAMOND RIVER | | | | | | |
| 29. | Grafton | Grafton Bleach & Dye Co. | Grafton Bleach & Dye Co. | 9 | 37 | 80 | 110 | 110 | | - |
| 30. | Grafton | Washington Emery Mills | Washington Emery Mills Mfg. Co. | 18 | 26 | 100 | 150 | 150 | | - |
| 31 | Grafton | Mass.Linen Thread Co. | Mass.Linen Thread Co. | 25 | 26 | 140 | 450 | 450 | | Mill idle. Hydraulic equipment complete. |
| | | | | SINGLETARY BROOK | | | | | | |
| 32. | Millbury | Mayo Mills | Mayo Woolen Co. | 60 | 5 | 35 | 145 | 145 | | Three falls, all in use. |
| 33. | Worcester | Auburn Textile Co. | Queensbury Mills Co. | 15 | 18 | 40 | 110 | 110 | | -- |
| 34. | Auburn | Pondville Mill | Pondville Woolen Co. | 20 | - | - | - | x | | - |
| | | | | MILL RIVER | | | | | | |
| 35. | Hopedale | Draper Corp. | Draper Corp. | 26 | 10 | 30 | 100 | | 100 | Equipment in place but not used since1922. |
| | | | | WEST RIVER | | | | | | |
| 36. | Uxbridge | S.F. Scott Sons | S.F. Scott Sons | 14 | 35 | 60 | 80 | | 80 | Hydraulic equipment abandoned.Water used for process. |
| 37. | Uxbridge | Waucantuck Mills | Waucantuck Mills | 8 | 35 | 30 | 50 | | 50 | " " |

x Undeveloped site.


BLACKSTONE
MILLVILLE
UXBRIDGE
NORTHBR
R.I.
MASS.
LEGEND
NORMAL WATER LEVEL
MARCH 1936 FLOOD LEVEL
MAXIMUM BRIDGE CLEARANCE
DAMS
SITE
CREST - ELEV. SHOWN
TOE - ELEV. SHOWN
CREST - ELEV. SHOWN
TOE - ELEV. NOT SHOWN
NOTES
EXISTING POWER DAMS NUMBERED TO CORRESPOND TO TABLE NO. 15
BRIDGES NUMBERED TO CORRESPOND TO TABLE NO. 19
ELEVATION IN FEET
MILES FROM MOUT
SOUTH MAIN ST DAM
BRANCH RIVER
MIDLAND DIV. R.R BRIDGE NO. 1 - ELEV. 183.08'
ST. PAUL ST. BRIDGE NO. 2 - ELEV. 165.48'
SARANAC DAM NO. 1
BRIDGE ST. BRIDGE NO. 3 - ELEV. 172.09'
N.Y. N.H & H. R.R BRIDGE NO. 4 - ELEV. 197.37'
BLACKSTONE MFG. CO. DAM NO. 2
N.Y., N.H. & H., R.R. BRIDGE NO. 7 - ELEV. 215.47'
MIDLAND DIV. R.R. BRIDGE NO. 6 - ELEV. 221.71'
N.Y., N.H. & H. R.R. BRIDGE NO. 8 - ELEV. 205.25'
WOODEN COVERED BRIDGE NO. 9 - ELEV. 205.04'
MILLVILLE DAM [WASHED OUT] NO. 3
CENTRAL ST. BRIDGE NO. 10 - ELEV. 210.05'
CENTRAL ST. BRIDGE NO. 11 - ELEV. 213.66'
WEST RIVER
MUMFORD RIVER
CONCRETE BRIDGE NO. 12 - ROUTE 122 - ELEV. 219.91'
N.Y., N.H. & H. R.R. BRIDGE NO. 13 - ELEV. 221.33'
HECLA MILLS CO. DAM [WASHED OUT] NO. 4
MENDON ST. BRIDGE NO. 14 - ELEV. 227.85'
RICE CITY DAM NO. 5
E. HARTFORD ST. BRIDGE NO. 15 - ELEV. 246.20'
CHURCH ST. BRIDGE NO. 16 - ELEV. 257.40'
KUPFER BROS. CO BRIDGE NO. 17 - ELEV. 261.14'
147.99' ELEV. CREST
159.58' ELEV. CREST - 154.30' TOE
191.80' ELEV. CREST - 179.80' TOE
206.51' ELEV. CREST - 192.30' TOE
224.19' ELEV. CREST - 217.60' TOE
236.03' ELEV. CREST - 228.20' TOE




MASSACHUSETTS
STATE PLANNING BOARD

# BLACKSTONE RIVER PROFILE
## AND FLOOD HEIGHTS MARCH, 1936

W. P. A. PROJECT NO. 13685

SCALE
HORIZONTAL 1 INCH = 2 MILES
VERTICAL 1 INCH = 40 FEET

DEC. 1937 | DATUM IS MEAN SEA LEVEL | 72-23C

f. Encroachment of Rural Buildings on Flood Plain

None

g. Cover and Adequacy

Forest cover in the Blackstone valley is at the present time adequate. (See Table 1 page 2). Most of the hillsides where serious erosion or accelerated run-off might occur are wooded. While much of the present cover would scarcely be termed forest, the sprout growths, cordwood lands and small timbers serve much the same purpose. Open lands so located as to be possible sites for soil erosion are usually well sodded pasture or occasionally turned hay lands. In the past, when the original timber was cut, soil erosion did take place and, as a result, the stream beds were heavily silted. The loss of soil impoverished some lands, but as natural reforestation took place erosion ceased. The main problem in the maintenance of cover as related to flood control is the preservation of present woodlands to prevent undue destruction.

2. Low Water Control

No low water control exists. Regulation is entirely a matter of the needs of the mills operating at the various privileges. (See Table 12 listing storage basins and existing reservoirs page 34.

B. Water Power

1. Developed Power

The Blackstone River has long been noted as one of the most completely utilized streams in the world. Not only has the fall on the main river been fully developed by dams built at various times along its course, but on the tributaries practically all of the potential power has been used at one time or another during the past century. In June, 1937, the total horsepower of the wheels installed was 9,740, as listed in (Table 15, page 45, and summarized in (Table 16, page 52).

Table 16

SUMMARY OF WATER POWER
FOR THE
BLACKSTONE VALLEY IN MASSACHUSETTS

| HYDRO-POWER | NUMBER OF FALLS | HEAD FEET | THEORETICAL H.P. 60% OF TIME | PRESENT INSTALLED H.P. |
|---|---|---|---|---|
| Developed and in use | 25 | 377 | 3310 | 6570 |
| Developed but not in use | 10 | 155 | 1175 | 2370 |
| Abandoned sites | 4 | 48 | 400 | 800* |
| TOTALS | 39 | 580 | 4885 | 9740 |

Most of the mills listed in the tables are of such size that their demands for power are in excess of the capacity of the stream, so that either steam from auxiliary plants or electricity from near-by transmission lines is now their main sources of power.

The elevation of the upper dam at the South Works of the American Steel & Wire Company, Worcester, is 440.70 feet. Of the total fall between this point and the tidewater in Rhode Island, 151 feet occurs in Rhode Island below the Saranac Mills of the American Woolen Company's privilege in Blackstone. Between the American Steel & Wire Company's dam and the Saranac Mills, American Woolen Company's tail water, there is thus a total fall of 287 feet. At the present time this 287 feet of fall in the Blackstone River in Massachusetts is utilized as follows:

99.5 feet is developed and in use.
33 feet is developed but now idle.
12 feet is developed but equipment in need of repair or replacement.
22 feet has hydraulic equipment but dam destroyed.
14 feet water used for process.
48 feet abandoned sites.
58.5 feet has no development of any kind.
287

*The data for rated installed capacity, and the head on all falls, was obtained by a field survey of the rivers and mills. The rated capacity of the installed hydraulic equipment, 9700 h.p., is double the theoretical power.

2. Undeveloped Power

Most of the undeveloped sites on the tributaries are of little importance because the amount of water available is limited, and none of the sites run as much as 50 h.p.

C. Water Supply

1. Municipal

The problem of municipal water supply in the Blackstone River valley is not critical. Only five towns lack substantially complete water supplies. These are Bellingham, Sutton and Upton with partial water supplies, and the towns of Mendon and Millville with no water supplies.

Detailed information of the various water supplies for all the municipalities in the valley is given in the following table:

Table 17

WATER SUPPLY CONDITIONS IN BLACKSTONE RIVER VALLEY

| TOWN | 1935 POPULATION | NUMBER OF SERVICES | PUBLIC / PRIVATE / DISTRICT | SOURCES OF SUPPLY | AVERAGE CONSUMPTION G.P.D.-1935 |
|---|---|---|---|---|---|
| Auburn | 6,535 | 513 P<br>- G | Auburn Water Co.<br>Woodland Park Water District | Dug & Tubular Wells<br>Worcester Water Supply | -<br>- |
| Bellingham | 3,056 | - G | District | Woonsocket, R.I. Water Supply | - |
| Blackstone | 4,588 | - G | Public | Woonsocket, R.I. Water Supply | - |
| Douglas | 2,403 | 260 P | Public | Tubular Wells | 188,000 |
| Grafton | 7,681 | 478 P<br>56 P&G | Grafton Water Co.<br>Saundersville | Dug & Tubular Wells<br>Dug & Tubular Wells | 168,000<br>- |
| Hopedale | 3,068 | - P | Public | (See Milford)<br>Dug Wells & Charles River | <br>- |
| Leicester | 4,426 | - G | Leicester Water Supply District | Dug & Tubular Wells | - |
| | | 560 P | Cherry Valley & Rockdale Water District | Dug Wells | - |
| Mendon | 1,265 | - | No Supply | - | - |
| Millbury | 6,879 | 939 P<br>51 P | Millbury Water Co.<br>Maple Hillside Water Co. | Dug Well<br>Worcester Water Supply Co. | 833,000<br>- |
| Millville | 1,901 | - | No supply | - | - |
| Northbridge | 10,577 | 687 P | Whitin Machine Works | Tubular Wells<br>Springs<br>Cook Allen Reservoir | 515,000 |
| Shrewsbury | 7,144 | 1,242 P | Public | Tubular & Gravel Packed Wells | 285,000 |
| Sutton | 2,408 | 84 P&G | Sutton Water Co. | Dug & Tabular Wells | - |
| Upton | 2,163 | - P | Knowlton & Sons Co. | Tubular Wells | - |
| Uxbridge | 6,397 | 878 P&G | Public | Tubular Wells<br>Springs | 236,000 |
| Worcester | 190,471 | 30,094 | Public | Kettle Brook Reservoir No. 1<br>Kettle Brook Reservoir No. 2<br>Kettle Brook Reservoir No. 3<br>Kettle Brook Reservoir No. 4<br>Lynde Brook Reservoir<br>Quinapoxet Pond<br>Upper Holden Reservoir<br>Lower Holden Reservoir<br>Kendall Reservoir<br>Pine Hill Reservoir | 14,829,000 |

P - Pumping
G - Gravity

2. Independent Industrial

The valley is very highly developed industrially, and the waters of the Blackstone and its tributaries are used extensively for manufacturing purposes. Industries were originally located here due to the availability of an excellent supply of pure water. Many of the streams have since become so grossly polluted that in some cases it has been necessary for the industries to develop independent supplies for manufacturing purposes or to obtain water from the municipality.

D. Stream Pollution and Waste Disposal

1. General Discussion

The city of Worcester and the towns of Hopedale and Northbridge have plants for what is termed the complete treatment of domestic sewage. A privately owned plant, operated by the William Knowlton Hat Company, located in the village of West Upton, partially treats the sewage and some of the industrial waste originating in this village. The rest of the towns dispose of their sewage by means of private sewers, consisting of a pipe line led to a convenient outlet, or by cesspools, septic tanks and privies.

The discharge of large amounts of industrial and domestic waste into the river and its tributaries has caused a high degree of pollution from Worcester to the Rhode Island state line. The unsightliness along the streams has been further accentuated by the general disposal of industrial waste, town refuse and rubbish.

The most unsanitary conditions have been created in Leicester, Millbury and Uxbridge by the promiscuous discharge of sewage from the large number of outlets in these towns. Sewage is also discharged from some of the other towns in the valley, and at times of high run-off a large amount of sewage and storm water is discharged from combined sewers in Worcester. Seepage from privies, cesspools and septic tanks located near the banks add to the pollution of the stream. Appendix D is a summary of the sanitary conditions as condensed from report on "Sources of Pollution of the Blackstone River Valley", prepared by the W.P.A. State Planning Projects.

2. Independent Industrial Waste

The major sources of industrial waste pollution are located in Worcester from the discharge of pickling liquors and other waste water from wire manufacture and the discharge of waste from a gas plant. Industrial wastes from the large number of woolen industries in the valley have caused offensive conditions in the main stream and many of its tributaries.

Table 18

VOLUME OF INDUSTRIAL WASTE DISCHARGED INTO STREAMS OF BLACKSTONE VALLEY

| TOWN | PRODUCT | VOLUME OF WASTES GALS. PER DAY | DISPOSAL |
|---|---|---|---|
| Leicester | Woolen cloth | 187,000 | Kettle Brook |
| Auburn | Woolen yarn | 53,000 | Kettle Brook |
| | Tallow, hides & fertilizer | 650,000 | Kettle Brook |
| | Woolen cloth | 27,000 | Ramshorn Brook |
| Worcester | Woolen cloth | 513,900 | Kettle Brook |
| | Wire | 52,100 | Kettle Brook |
| | Machine Knives | 17,500 | Tatnuck Brook |
| | Machine Knives | 81,000 | Beaver Brook |
| | Clean clothes | 20,000 | Settling tank & filter. Effluent to Tatnuck Brook |
| | Wire | 35,000 | Middle River |
| | Woolen cloth, cotton & linen yarn | 155,000 | Middle River |
| | Electricity | 468,000 | Middle River |
| | Wire | 3,468,600 | Mill Brook Channel |
| | Gas and by-products | 200,000 | Mill Brook Channel |
| | Wire | 3,113,400 | Blackstone River |
| Millbury | Scoured wool | 54,000 | Lagoon and Ramshorn Brook |
| | Scoured wool | 55,000 | Singletary Brook |
| | Linen & cotton thread | 44,000 | Singletary Brook |
| | Woolen cloth | 154,000 | Singletary Brook |
| | Scoured wool | 55,000 | Lagoon, seepage to Blackstone River |
| | Wire | 82,000 | Blackstone River |
| | Felt | 122,800 | Blackstone River |
| | Clean clothes | 8,450 | Blackstone River |
| | Woolen cloth | 630,000 | Blackstone River |
| Sutton | Clean clothes | 7,000 | Cold Spring Brook |
| | Carbonized shoddy | 30,000 | Part to cesspool, part to Mumford River |
| Grafton | Yarn | 9,000 | Quinsigamond River |
| | Woolen cloth | 800,000 | Blackstone River |
| Douglas | Woolen cloth | 1,170,000 | Mumford River |
| Northbridge | Spinning rings, Textile machinery, cotton goods | Small amounts from 3 plants | |
| | Colored paper | 5,000 | Blackstone River |
| | Rayon cloth | Small amount | Blackstone River |
| Upton | Felt hats | 100,000 | Part to sewage disposal plant, part to W. River |
| Uxbridge | Woolen cloth | 1,600,000 | Mumford River |
| | Woolen cloth | 530,000 | West River |
| | Woolen cloth | 252,000 | Blackstone River |
| | Carbonized and dyed shoddy | 35,000 | Blackstone River |
| Hopedale | Shuttles | 15,000 | Mill River |
| Mendon | Shoddy | 35,000 | Mill River |

## E. Irrigation and Drainage

### 1. Existing Irrigation

a. Use. Because of the uniform distribution of adequate rainfall throughout the year there is no irrigation in the valley except for 16 acres (cranberry patch) in the town of Hopkinton near North Pond.

### 2. Existing Drainage

There are no areas which have artificial drainage.

## F. Inland Water Recreation and Wildlife

The Blackstone River is essentially an industrial stream, and cannot be intensively developed for recreation. There is some canoeing, but the landscape is not extremely attractive, and too many portages exist for convenience. Fishing is poor, due to stream pollution. A few of the headwater bodies and streams offer bathing, boating and reasonably good fishing. Wildlife is chiefly confined to the small game types such as fox, rabbit, raccoon, squirrel, and to game birds such as pheasant, quail and woodcock. There is a limited stock of deer.

There are four state forests and one state reservation partly or wholly within this area which offer outdoor recreation opportunities.

| | | |
|---|---|---|
| Douglas State Forest | 3,735 acres | located in the town of Douglas |
| Spencer State Forest | 1,016 acres | lying in the towns of Spencer and Leicester |
| Sutton State Forest | 600 acres | in the town of Sutton |
| Upton State Forest | 2,528 acres | in the towns of Upton and Northbridge |
| Purgatory Chasm State Reservation | 80 acres | located in Sutton |

In addition to these state areas there are numerous local municipal parks providing some opportunities for active recreation. The State maintains two fish hatcheries located in Sutton;the Sutton State Fish Hatchery of 22.74 acres, and the Sutton Pond System of 180.23 acres.

## G. Navigation

The Pawtucket (Seekonk) River is navigable from its mouth to Pawtucket, R.I., a distance of 5.2 miles. The channel is 16 to 18 feet deep at mean low water, and 150 to 230 feet wide as far as the ledge rock area between the Pawtucket wharves. From this point upstream 0.2 miles to Division Street bridge the channel narrows to

60 to 100 feet, and the depth remains the same. At the present time the controlling depth in the upper reach is about 13.5 feet. The mean tidal range is about 4.7 feet at the mouth and 5.0 feet at Pawtucket.

Since the abandonment of the canal in 1848 none of the upper portions of the river have been used for navigation purposes.

## CHAPTER V

## PROBLEMS AND PROPOSALS FOR SOLUTION

### A. Flow Control

#### 1. Flood Control

It is apparent from the total flood damage loss suffered during March, 1936, that the construction of detention basins or reservoirs does not seem to be justified at this time. The total estimated direct damage in the Blackstone valley amounted to approximately $1,609,153, but on analysis a great deal of this damage could be attributed to negligence. This is clearly indicated in the complete listing of all damage in Appendix C. All the possible detention basin sites selected from U. S. G. S. topographic sheets were indicated on a special map. High flowage damage and other costs make the consideration of most of them doubtful at this time.

It is possible that with the formation of the mill owners' committee, as indicated in paragraph i, page , and the creation of a flood district, some of these sites would be considered in connection with power.

Above the Worcester-Millbury line there is an approximate drainage area of 65.5 square miles. The city of Worcester, which lies within this area, suffered a flood damage of approximately $700,000. Within this area there are no economical flood control reservoir sites. The question of flood relief for this area has been discussed in a special report by the engineering department of the city of Worcester*. The improvement suggested include a by-pass for the Kettle Brook area, some channel improvement on the main river, together with some tunnel construction for the Quinsigamond area, and a diversion for Leesville area. Inasmuch as most of these improvements materially increase flows in the main stream, they would probably be matters for committee or interstate consideration.

*See Appendix G

a. Reservoirs and Detention Basins

As a preliminary step before field investigation, an attempt was made by the Works Progress Administration engineers to locate on the U. S. G. S. topographic sheets all possible sites where additional storage or a detention basin could be located. About 28 such sites were located on the maps. These sites included the three basins which were surveyed by Mr. John R. Freeman in 1906; located one each on the Peters, Mill and West Rivers. The list includes many locations which must of necessity be eliminated because of excessive costs or local damage. On none of the sites selected by the project engineers were surveys sufficiently advanced to decide on their ultimate feasibility. Where construction costs appeared low and promising, data as to property damage and rights to be acquired were lacking. In some cases it is apparent that this property damage would be excessive. None of the sites selected showed sufficient promise for immediate recommendation, but it is possible on a more extended survey that out of the 28 sites one or two might show justification if considered in connection with power, flood control, sewage dilution, and other uses on an interstate basis.

b. Channel Improvements

Although the channel conditions along the Blackstone River have been shown to be unnecessarily bad, it is not believed that a general construction program for improvement should be made at this time. The excessive costs would not justify the benefits. It is recommended that a general clean-up be made of the accumulated debris, including the removal of overhanging trees and any obstructions brought about by general neglect. This clean-up would go a long way toward bettering flood conditions from Worcester to the Rhode Island state line. Any plans for extensive channel improvement call for joint action by Massachusetts and Rhode Island. General plans have been made and are on file with the Massachusetts State Planning Board. These are listed in Appendix E. Flood-provoking conditions such as the disposal of rubbish and general waste by both towns and industries should be prohibited. Bridge openings which are inadequate should be enlarged. The restricted openings at the bridges are shown on special bridge plans filed with the Massachusetts State Planning Board. Table 19, which follows, lists all the bridges on the Blackstone River, some of which had little clearance or were submerged during the March, 1936 flood. This is indicated by the bottom elevation of the lowest bridge member, normal water level and the elevation attained by the flood.

Table 19

BRIDGES - BLACKSTONE RIVER

| NO. | TOWN OR CITY | NAME | MILES FROM STATE LINE | LOWEST MEMBER ELEV. | NORMAL WATER | FLOOD ELEV. 1936 | R.R.CO'S BRIDGE NUMBER |
|---|---|---|---|---|---|---|---|
| 1. | Blackstone | State Line Bridge | .14 | 183.08' | 152.7' | 164.00' | #34.64 |
| 2. | " | St. Paul St. " | .42 | 165.48' | 153.0' | 165.20' | |
| 3. | " | Bridge St. " | .70 | 172.09' | 162.30' | 169.50' | |
| 4. | " | R. R. | .88 | 197.37' | 162.40' | 171.52' | #17.92 |
| 5. | " | Midland Div. R. R. Bridge | .88 | 181.61' | 152.4' | 171.40' | #35.65 |
| 6. | Millville | R. R. Bridge | 2.85 | 221.71' | 192.3' | 202.00' | #37.67 |
| 7. | " | R. R. Bridge | 2.85 | 215.47' | 192.3' | 201.90' | #19.40 |
| 8. | " | R. R. Bridge | 3.20 | 205.25' | 193.0' | 203.10' | #19 72 |
| 9. | " | Covered Bridge | 3.44 | 205.04' | 193.2' | 204.20' | |
| 10. | " | #1 Central St." | 3.78 | 210.05' | 200.2' | 209.50' | |
| 11. | " | #2 " " " | 3.78 | 213.66' | 200.2' | 209.20' | #2 |
| 12. | Uxbridge | Concrete Bridge Route 122 | 7.26 | 219.91' | 208.4' | 219.50' | |
| 13. | " | R. R. Bridge | 7.45 | 221.33' | 208.5' | 220.80' | #23.19 |
| 14. | " | Mendon St. Bridge | 10.23 | 227.85' | 219.0' | 228.75' | |
| 15. | " | E. Hartford St." | 12.36 | 246.20' | 236.6' | 245.20' | |
| 16. | Northbridge | Church St. " | 15.80 | 257.40' | 245.4' | 259.05' | |
| 17. | " | Kupfer Bros. " | 16.70 | 261.14' | 257.60' | 265.00' | |
| 18. | " | Highway " Route 122A | 17.80 | 264.14' | 258 2' | 268.00' | |
| 19. | " | Paul Whitin Co." | 18.20 | 268.09' | 258.80' | 271.50' | |
| 20. | Grafton | Wascanut Mills Bridge | 20.30 | 282.32' | 270.0' | 281.90' | |
| 21. | " | Highway Bridge Route 122A | 21.00 | 285.55' | 278.7' | 286.20' | |
| 22. | " | Pleasant St. Bridge | 22.5 | 302.82' | 294.90' | 303.80' | #3 |
| 23. | " | Pleasant St. Bridge | 22.5 | 299.87' | 294.9' | 308.50' | #2 |
| 24. | " | Pleasant St. Bridge | 22.5 | 297.13' | 294.9' | 308.50' | #1 |
| 25. | " | R.R. Trestle Bridge | 22.88 | 308.85' | 296.6' | 307.50' | #34.30 |
| 26. | Sutton | Mill St. Bridge | 23.70 | 325.43' | 309.5' | 323.00' | |
| 27. | " | R. R. " | 24.25 | 340.11' | 317.00' | 331.50' | #35.29 |
| 28. | " | Pleasant St. Bridge | 24.25 | 331.88' | 319.0' | 331.00' | |
| 29. | Millbury | Cross St. Bridge | 24.90 | 339.86' | 333.5' | 343.30' | #2 |
| 30. | " | " " " | 24.90 | 337.03' | 333.60' | 343.30' | #1 |
| 31. | " | Riverlin St. Bridge | 25.90 | 352.25' | 347.7' | 356.50' | |
| 32. | " | Providence St. Bridge | 26.00 | 357.16' | 349.30' | 358.20' | |
| 33. | " | South Main St. Bridge | 26.30 | 385.87' | 367.80' | 375.20' | |
| 34. | " | R. R. Bridge | 26.50 | 392.20' | 382.10' | 388.10' | #37.33 |
| 35. | " | Elm St. " | 26.70 | 406.08' | 381.4' | 388.40' | |
| 36. | " | R. R. " | 27.00 | 398 86' | 389.4' | 391.50' | #37.74 |
| 37. | " | Felters Co. Bridge | 27.25 | 395 75' | 390.4' | 394.75' | |

BRIDGES - BLACKSTONE RIVER
(Cont'd)

| NO. | TOWN OR CITY | NAME | MILES FROM STATE LINE | LOWEST MEMBER ELEV. | NORMAL WATER | FLOOD ELEV. 1936 | R.R.CO'S BRIDGE NUMBER |
|---|---|---|---|---|---|---|---|
| 38. | Millbury | Providence Pike Bridge | 28.25 | 408.72' | 398.6' | 406.50' | |
| 39. | " | Macracken St. Bridge | 28.40 | 403.27' | 398.8' | 408.50' | |
| 40. | " | Highway Bridge Route 20 | 29.30 | 435.95' | 405.30' | 413.50' | |
| 41. | Worcester | Millbury St. Bridge | 30.60 | 419.92' | 415.5' | 426.50' | |
| 42. | " | A.S.&W. Co. Bridge | 31.25 | 441.17' | 432.17' | 447.00' | |
| 43. | " | R. R. Bridge | 31.30 | 440.16' | 433.10' | 441.20' | #41.41 |
| 44. | " | Middle River Rd. Bridge | 32.14 | 447.35' | 445.1' | 451.20' | |
| 45. | " | Southbridge St. Bridge | 32.42 | 448.36' | 445.2' | 448.75' | |
| 46. | " | R.R. Bridge above Southbridge St. | 32.70 | 461.34' | 456.6' | 461.00' | #68.92 |
| 47. | " | Fremont St. Bridge | 33.30 | 467.39' | 461.2' | 470.20' | |
| 48. | " | R.R. Bridge on Main Line | 33.42 | 473.86' | 461.3' | 467.50' | |
| 49. | " | R. R. Bridge at Reed & Prince Mfg. Co. | 33.50 | 469.66' | 461.3' | 470.40' | |
| 50. | " | Webster St. Bridge, Kettle Brook | 33.70 | 470.14' | 464.30' | 470.00' | |
| 51. | " | Worcester Elec. Light Co. Bridge | 33.75 | 474.48' | 464.3' | 482.40' | |
| 52. | " | Worcester Elec. Light Co. 2nd Bridge | 34.25 | 474.78' | 464.3' | 471.00' | |
| 53. | " | R. R. Bridge Curtis Pond | 34.70 | 496.86' | 473.6' | 493.50' | #47.16 |
| 54. | Auburn | Leesville Bridge | 35.25 | 482.40' | 476.1' | 482.00' | |

c. Raising Structures

It is recognized that a complete re-construction program would be impossible on account of the tremendous costs involved. The raising of highway bridges involves the re-grading of approaches, street grades and other complications. Some work has been done by the Public Utilities in raising and re-locating their equipment so as to lessen flood dangers. Factories have likewise profited by their experiences in storing flood-perishable products. Roadways damaged by the flood have been repaired. In most cases within the area it will be found cheaper to replace flood-damaged highways than to re-locate them.

d. Dikes

An examination of the river from Worcester to the Rhode Island state line does not indicate that diking would be practical or economical.

e. Erosion Control

Generally erosion is not a problem except at bridge approaches where planting or similar measures will be effective.

f. Rehabilitation and Zoning of Areas Subject to Floods

Zoning ordinances should be revised or promulgated, and building codes amended so that dwellings shall not be constructed, and commercial structures limited according to the hazards presented in each definite area. This may require state legislation to be effective. Pending such local zoning as may be proposed by the various municipalities it is suggested that all areas subject to flooding be marked by having monuments or markings placed at critical points showing plainly the elevation attained by freshet rises or floods, as a direct warning to occupants.

g. Reforestation

The problem confronting the Blackstone valley is the maintenance of the present forest cover rather than the re-forestation of new areas, since only limited sections on slopes important in relation to floods have been cleared, and any plan would only have a slight effect upon the run-off. It is possible, however, that in the future, through the State Department of Forestry and Conservation, some plan may be devised whereby important slope areas can be protected by public ownership or private ownership under supervisory control.

The fact that the problem of maintaining the present forest cover is unsolved is illustrated by the recent clearing of important slopes on a small privately owned area above Rice City Pond near the Northbridge town line.

h. Justification of Flood Control

It is recognized that flood-control measures offering some assurance to property owners in areas subject to flooding increase property values, which, in turn, offer better returns in taxation. Inasmuch as a great deal of the damage has been caused by neglect of channel conditions, it is believed that the recommendations under paragraph b would go a long way toward alleviating much of the damage suffered,and would be the best preliminary program to follow pending interstate action. The topography of the region furnishes many possible sites for detention basins, but, unfortunately, towns, railroads, industrial developments and summer cottages have occupied the most likely sites, so that only at prohibitive costs can they be taken over for flood-control purposes. Flood control is a business proposition, and the cost of preventing damage must not exceed the damage itself averaged over a period of years and capitalized.

i. General Policy of Flood Control

Flood control in the Blackstone valley is a matter for interstate consideration. It is a question whether major channel improvements along the Massachusetts portion of the river alleviating flood conditions in this state might not at the same time, due to increased capacity of the channel,pass along much larger peak quantities of water, thus causing more serious conditions in Rhode Island.

Flowage rights are so vested at each point where there is a privilege that only an absolute agreement among the owners themselves could bring about any changes in flow conditions. While the present storage is comparatively high, many of the ponds are badly silted, reducing their effective storage. It is possible that through a Commission in Massachusetts, in conjunction with the State of Rhode Island and the various mill owners,some sort of palliative flood-control measures can be adopted involving the partial emptying of all the present storage basins in the watershed, depending upon snow cover and other conditions which might indicate flood dangers. The various reservoirs could thus be drawn down to take care of expected freshet flows. Such a plan would be possible only through the co-operation of all the owners of flowage rights, and could only be successful if the entire valley was operated as a flood-control district, either by the mutual consent and co-operation of all parties concerned, or the creation of a flood district by law.

2. Low Water Control

Due to the high degree of control exercised at the various

privileges, regulation is entirely in the hands of the mill owners. There is every indication that the cost of additional reservoirs or detention basins would be excessive, and while further study is needed pending such surveys, no recommendations which seem feasible or economical can be offered.

3. Relation of Flow Control to Other Uses

The general clean-up of the river channel, as recommended in this study, will have little or no effect upon other water uses.

B. Water Power

1. Potential Power

It is probable that few, if any of the limited number of sites worth consideration will ever be developed for economic reasons. Under the Works Progress Administration Planning Projects surveys were made at various water privileges and dam sites for the re-development or re-construction. The results of this survey, which may be a matter for future consideration, will be found in Appendix G.

2. Economical Feasibility

In a general investigation of power development the United States Engineers in 1929 reported as follows:

"Study of the United States Geological Survey maps,which cover the entire basin,indicates that there are a few sites on the tributary streams where additional storage might be created to increase the water power at existing mills along the stream below by impounding the surplus flow during the wet months of the year, usually from December 1 to May 31. The most promising of these sites were selected for consideration as to their economic value. While seeking for available data on the subject it was found that the same question had been investigated on at least five occasions since 1849 for groups or committees of the mill owners. Although some favorable reports,based on scant surveys, had been submitted - the last in 1900 - no further action toward erection of reservoirs was taken on the part of the manufacturers. In 1906 the entire subject was investigated anew by Mr. John R. Freeman, an engineer of national reputation,who spent several months looking up possible sites, determining their merits and preparing an exhausting report.

"Topographical surveys of the most promising reservoir and dam sites were made, including test borings at four dam sites that appeared most favorable. After a thorough study of the matter,wherein errors in previous reports and the reasons therefor were clearly shown, his conclusions were, in brief:

"That the amount of coal consumption that could be saved to

your present steam power plants by means of additional water that these reservoirs would make available for power on your turbines, will not yield an attractive percentage of income on the cost of the reservoirs for any of the ten sites investigated.

"These sites included all that offer any hope of being developed at a reasonable cost. Seven of them are in Rhode Island (six on Branch River and one on Cherry Brook); the other three are in Massachusetts, one each on Peters, Mill and West Rivers.

"It is recognized by the water power owners that some of their wheels are not producing the full amount of power available at their privileges. In some instances the equipment is old and inefficient;in others the plan of development is more or less antiquated and faulty in design; and in addition, above several of the dams the pondage capacity has become greatly reduced by the gradual deposit of silt and the growth of vegetation in the shallow waters or partly covered flats. Such modifications as are needed in these installations to increase their output are matters of greatest interest to the individual owners who are using the power,and these owners will naturally continue to make the desirable changes whenever industrial conditions are favorable and financial benefit to themselves is positively assured.

"Any possible improvements or even re-developments in these relatively small privately owned installations are too minor in character and extent to be of public concern, and are, therefore, considered irrelevant to the present investigation.

"At some of the smaller available power sites, due to the low head and lack of pondage under their control, the owners have not found it economical to re-develop these privileges, and in many cases it is probable that they will not again be used for power purposes."

3. Relation to Increased Flow

The possibility of increased flow and storage with relation to water power and flood control is discussed in paragraph i, page 50.

C. Water Supply

1. Municipal - Extensions, New Systems, Treatment

Under sponsorship of the Massachusetts Department of Public Health the W.P.A. State Planning Projects have made studies relative to the solution of municipal water supply problems. Surveys have been completed and preliminary plans and cost estimates made for new water supply systems for the towns of Upton, Millville, the village of Manchaug in Sutton, and the Elm Hill district of Auburn. Plans and cost estimates have also been made of the extension of the present distribution system of Blackstone, and for a new source

of supply. Estimates of cost of these proposed water supply systems follow:

| | |
|---|---|
| Blackstone (extension of present system) | $128,000 |
| Blackstone (new supply and system) | 190,000 |
| Millville | 125,000 |
| Upton | 187,000 |
| Village of Manchaug in Sutton | 64,000 |
| Elm Hill District of Auburn | 79,000 |

2. Independent Industrial

The potential use of the streams for industrial water supply depends entirely upon improvement of conditions now existing. New methods of disposal and treatment of domestic and industrial wastes as planned will enable the industries of the valley to use the water of the streams to a greater extent than at present.

3. Relation to other Water Uses - Power, Pollution and Recreation

The effect of reservoirs (if constructed) for future water supply will not be great, due to their small size. Only the headwater of the streams can be developed as sources of supply, since the main stream and many of its larger tributaries are too highly polluted to be used. It is quite probable that future sources of supply for most of the towns will be developed from ground water which will have a negligible effect upon the stream and other water uses.

D. Stream Pollution and Waste Disposal

The State Department of Health is well aware of the deplorable sanitary conditions which exist on the Blackstone River. It has a capable technical staff; its studies of water and sewerage purification conducted at the Lawrence Experiment Station have developed basic methods and standards which have been adopted by authorities throughout the world.

There must be a realization that the waterways are the "highways" by which a limited amount of waste matter must be taken care of; that the Blackstone is essentially an industrial stream; that its industrial importance comes before any recreational advantages which might be suggested.

It is recognized that gross pollution abuses exist which cannot be remedied for lack of State authority. Problems which originate in a town can sometimes be handled by local authorities, but often the nuisances complained of are not serious or considered at the point of origin.

1. Municipal Sewage Disposal - Extensions, New Systems, Treatment

Department of Public Health studies were also sponsored in certain of the municipalities relative to new methods of sewage disposal. Field surveys were made and preliminary plans and cost estimates prepared for proposed sewerage systems and treatment plants for the towns of Blackstone, Millville, Uxbridge, Millbury and the village of East Douglas. Complete treatment of the sewage is proposed in all cases, consisting of screening, plain sedimentation and sand of trickling filtration, depending upon the head and area available at the treatment sites. Studies are under way at the present time for new sewerage systems in other municipalities. Estimates of cost of these proposed sewage treatment plants follows:

| | |
|---|---|
| Blackstone | $314,000 |
| Millville | 225,000 |
| Uxbridge | 651,000 |
| Millbury | 591,000 |
| Douglas | 365,000 |

2. Independent Industrial

No specific recommendations. See statement on Industrial Waste in Introduction to Water Resources Studies, Page xxv.

3. Relation to other Water Uses

Any abatement in domestic or industrial waste pollution would proportionately increase the value of the stream for industrial water supply purposes and enhance recreational usage.

E. Irrigation and Drainage

1. Irrigation

Not profitable. Basin has ample rainfall for ordinary agricultural practice.

2. Drainage

Not considered a problem.

F. Inland Water Recreation and Wildlife

Since the Blackstone River is highly industrialized and polluted, there is no particular incentive for general recreation in or along its course unless these conditions are corrected. Present draw-down requirements for industrial purposes create unsightly conditions along the river and the shores of many lakes and reservoirs.

1. Bathing

There are many ponds and lakes which offer opportunities for public beach developments. Prevailing draw-down conditions will determine their advisability for development. Beach improvements should be primarily local. It is recommended that extensions be made to the Douglas State Forest along the shores of Manchaug and Willis Ponds, thus providing additional sports areas of all types.

2. Boating

No recommendations are made except to state that the removal of the pollution menace and some obstructions might induce canoeing on some sections of the river.

3. Fishing and Wildlife

The Massachusetts State Planning Board has underway a recreation field study. This, when completed, will contain among other subjects suggestions relative to areas which should be acquired for wildlife preserves.

While most of the headwater lakes and ponds now offer reasonably good fishing, more ideal conditions may be brought about by a broader restocking program and a conscious relationship between fish culture and industrial uses of the reservoirs.

There is need of increasing the supply of food materials for fish and wildlife and clearing streams now clogged with brush growth and debris. A program should be developed to conserve the wildlife resources conforming to any improvements undertaken to better existing conditions.

4. Scenic and other Interest

Since industrial conditions prevail on the main stream, pollution and reservoir draw-down cause conditions which are not conducive to a rounded recreational program. For this reason, recreational improvements along the main stream should be confined to areas where the principal assets are woodland scenery or overlook features of sufficient interest to encourage picnicking, camping, hiking and possible winter sports. There seems to be little justification for many large recreational improvements of state-wide

interest at this time. The only areas of size to be recommended for consideration, aside from the state-owned forest lands, are the hills on each side of Rice City Pond near North Uxbridge, and certain lands adjacent to Douglas State Forest which should be acquired.

There are many sites which could be developed for local parks, town forests, roadside picnic areas and wildlife preserves. It is recommended that present publicly owned areas be further improved.

G. Navigation

Not practical.

# A P P E N D I C E S

APPENDIX A

CHAPTER 248 OF THE ACTS OF 1936

(FOR AMENDMENT SEE CHAPTER 410 BELOW)

AN ACT CREATING THE BLACKSTONE RIVER VALLEY DISTRICT AND DEFINING ITS POWERS AND DUTIES.

Be it enacted, etc., as follows:

SECTION 1. A river valley improvement district, to be known as the Blackstone River Valley District, hereinafter called the district, is hereby created within the watersheds of the Blackstone River and the Ten Mile River. The district shall include all the territory of the municipalities of Auburn, Bellingham, Blackstone, Douglas, Grafton, Hopedale, Leicester, Mendon, Millbury, Millville, Northbridge, Plainville, Shrewsbury, Sutton, Upton, Uxbridge and Worcester.

SECTION 2. The district shall be under the management and control of an unpaid board, which is hereby created and shall be known as the Blackstone River Valley District Board, hereinafter called the board. The board shall consist of the mayor of the city and the chairmen of the boards of selectmen of the towns in the district other than Millville, and in the case of Millville the chairman of the Millville municipal finance commission, and five persons, residents of the district, who shall be appointed, and may for cause be removed, by the governor, with the advice and consent of the council. In the original appointments of said appointive members, two shall be appointed for the term of three years, two for the term of two years and one for the term of one year, and thereafter as the term of office of an appointive member expires his successor shall be appointed in the manner for the term of three years. Every member shall serve until the qualification of his successor. The board shall annually on April first designate the chairman of the board.

SECTION 3. The district shall have a seal consisting of a circular die bearing the words "Commonwealth of Massachusetts. Blackstone River Valley District, 1936", which seal may be used, whenever deemed advisable by the board, on notes or other evidences of indebtedness, papers and documents issued or executed by the board or by any officer of the district thereunto authorized by the board.

SECTION 4. The board may appoint and may at pleasure remove a treasurer and a clerk, who need not be members of the board, and both offices, if the board deems it advisable, may be held by the same person. The treasurer shall give to the board a bond payable

to the district with a surety company authorized to transact business in the commonwealth and satisfactory to the board as surety, in such sum as the board may prescribe and conditioned on the faithful performance of his duties. The clerk shall take oath to faithfully and impartially perform his duties. The duties of the treasurer and the clerk shall be those usually appertaining to said offices, respectively, and in addition such as may from time to time be prescribed by the board. The compensation of the treasurer and of the clerk shall be determined by the board. The board may also appoint and determine the compensation of, and may at pleasure remove, a chief engineer, who shall direct the engineering work and act as executive manager of the district. The compensation of persons appointed under authority of this section shall be paid by the municipalities of the district, except Millville, and shall be considered as a part of the expense of maintenance of the district.

The board shall secure convenient quarters for an office and for the keeping of maps, plans, documents and other papers relating to the business of the board. It shall at all times keep full and accurate accounts of its receipts, expenditures, disbursements, assets and liabilities, and shall annually on or before December thirty-first make a written report to the governor and council.

SECTION 5. No financial obligation shall be incurred and no money shall be expended under this act unless and until at least three hundred thousand dollars shall have been allocated by the federal government under authority of appropriate federal legislation for one or more of the projects authorized by section six, and no work on any such project shall be commenced unless and until sufficient funds therefor shall have been allocated by the federal government as aforesaid.

SECTION 6. The board, acting for the district, may construct any or all of the following projects, and thereafter shall maintain and operate the same:-

(a) Dams and reservoirs for the impounding and storage of the waters of the Blackstone River and of the Ten Mile River, or either of them, and for the regulation of the flow of the waters thereof, and works, including dredging, for the improvement of navigation thereon and flood control thereof and of the sanitary condition thereof; and in connection therewith the board may provide and maintain the necessary pipes, conduits, plants, stations and equipment for the distribution and delivery of said waters within the district;

(b) Subject to the approval of the State Department of Public Health, works for supplying water for the purpose of extinguishment of fires and for domestic use of the inhabitants of the district and in connection therewith the board may lay and maintain the necessary water mains, erect or acquire, and maintain, the necessary pumping stations and filtration plants and do all other

incidental work necessary or convenient to enable the district to distribute water to said inhabitants, with authority to fix and collect the rate for the sale of said water;

(c) Such roads, bridges and canals in the district incidental to and reasonably necessary for the construction, use or operation of any or all of the structures and works authorized by this act;

(d) Public parks, boulevards and areas for reforestation and the cultivation and production of timber, and for the preservation of wildlife and natural resources, at and along such portions of the marginal lands of either both of said rivers as the board may deem proper;

(e) Subject to the approval of the State Department of Public Health, such trunk sewers, pumping stations, intercepting sewers, connections and other sewerage works as may be required for a system for suitably treating, disposing of or diverting from the waters of the Blackstone River and the Ten Mile River, or either of them, sewage and other pollution originating in the territory of the district;

(f) Such retaining walls, piers or other works as will prevent soil erosion in said rivers, or either of them, and any other structures that will improve navigation thereon.

SECTION 7. The board may make such contracts and enter into such other arrangements as it may deem necessary for the construction, operation and maintenance of any or all of the works hereinbefore authorized, may purchase necessary materials and supplies therefor and may secure necessary labor therefor. Every contract calling for an expenditure of more than five hundred dollars shall be in writing, and no such contract shall be awarded unless proposals for bids therefor shall previously have been published once a week for three successive weeks in two daily papers published in Worcester county. Such bids shall be opened publicly at the time and place announced in such newspaper publication.

SECTION 8. In carrying out the powers and duties conferred and imposed upon the board by this act, the board may locate and maintain water pipes and poles and wires for the transmission of electricity, and any other necessary equipment, in, on, or over public ways, and in or over railroad or railway locations, and it may alter or change the location or grade of any way, provided that it shall not take in fee any land of any railroad or railway corporation, nor enter upon or construct any drain, sewer or other works within the location of any railroad or railway corporation, except at such times and in such manner as it may agree upon with such corporation, or, in case of failure so to agree, as may be approved by the State Department of Public Utilities; and provided, further, that in entering upon and digging up, raising or embank-

ing any way, the board shall be subject to such reasonable regulations as may be made by the mayor, aldermen, city council, selectmen, or other officials having jurisdiction in the premises, in the municipality in which such work is performed. In case of dispute between the board and any such municipality, the question at issue shall be determined by the State Department of Public Works.

SECTION 9. For any purpose authorized by this act the board, acting on behalf of the district, may take by eminent domain under chapter seventy-nine of the General Laws, or acquire by purchase or otherwise, such lands, water courses, rights of way or other easements, property and rights therein as it may deem necessary. Any person, corporation or municipality whose property has been taken or injured by any action of the board under authority of this act may recover from the district under the provisions of said chapter seventy-nine such damages therefor as he or it may be entitled to. The board may sell at public auction any property, including land, acquired by it hereunder and in its opinion no longer needed in the performance of the powers and duties conferred and imposed upon it by this act. The board may enter upon any lands or waters for the purpose of making surveys, test pits and borings, and may take by eminent domain under said chapter seventy-nine or acquire by purchase or otherwise the right to temporarily occupy any lands necessary for the carrying out of any of said purposes.

SECTION 10. The board may furnish water to any municipality or legally constituted district within the district created by this act, and for that purpose may connect the mains of the district with existing mains and may locate any necessary works required for the distribution of the water in and upon any private or public location within any such municipality or such legally constituted, district and may connect private sewers, or new sewers under construction, with any existing sewers, and may operate sewerage systems within the district created by this act upon such terms, conditions and regulations as the board may prescribe. The board may levy assessments upon any person for the privilege of using the sewerage facilities furnished by it. So far as apt, the provisions of sections twelve and thirteen of chapter eighty of the General Laws shall apply to such assessments.

SECTION 11. Annually before January first the board, on behalf of the district, shall certify to the assessors of each municipality within the district, except Millville, the sum constituting the share of such municipality of the estimated cost for the ensuing year, over and above receipts of the district, of the maintenance and operation of the works maintained and operated by the board under authority of this act and also the share of such municipality of any deficit for the then current or any preceding year; and the amount so certified shall be raised by the assessors of such municipality during said ensuing year, and shall be paid, not later than November first, into the treasury of the district. Each

such municipality, except Millville, shall be annually assessed hereunder such proportion of such cost of maintenance and operation as the board shall determine, based upon the proper proportion of such municipality of the benefit derived by it from the works so maintained and operated hereunder. If any municipality is aggrieved by the assessment made upon it hereunder, the respective amounts to be paid by the municipalities of the district, except Millville, shall be determined by three commissioners to be appointed by the supreme judicial court upon the application of such aggrieved municipality and after notice to the other municipalities of the district. The award of said commissioners when accepted by said court shall be binding upon the municipalities of the district.

SECTION 12. For the purposes of paying the expenses of the construction of the work hereinbefore authorized, the district is hereby empowered to receive from the federal government all sums of money allocated by it for any or all of the purposes of this act, but the board shall have no right to levy upon,or to charge or collect against, any municipality in the district any portion of the cost of such construction. All expenses of construction, including in said term all land damages, costs of plans and surveys,and other necessary items of construction, but excluding compensation authorized by section four,shall be paid for exclusively out of such federal funds so allocated.

Upon the completion of any of such works, the district shall thereafter bear the entire expense of the operation and maintenance thereof.

SECTION 13. For the purpose of temporarily financing the operation and maintenance of works constructed under authority of this act, including compensation, the district may issue its notes to an amount deemed by the board necessary therefor, but not to exceed the estimated cost of such operation and maintenance, said notes to be payable, in not more than one year from the date of their issue, from sums received by the board as a result of the operation and maintenance of such works and from sums certified to and collected from the several municipalities of the district, except Millville, as hereinbefore provided. The provisions of chapter forty-four of the General Laws relating to the issue of notes by districts shall, so far as pertinent, apply to notes issued under this section.

SECTION 14. If and when there is established within the state of Rhode Island a board similar to the board created by this act, with similar powers and duties within that portion of the watersheds of the Blackstone and Seekonk Rivers and their tributaries lying within said state, the board established hereunder is hereby authorized to act, as hereinafter provided, jointly with said Rhode Island board. Said joint body shall be known as the Blackstone and Seekonk River Valley Authority, and is hereinafter referred to as

the authority. The authority shall act as an advisory planning board relative to all works and projects deemed by it reasonably necessary and proper for the preservation and maintenance of the health, welfare and safety of the inhabitants of the watersheds of the Blackstone and Seekonk Rivers and their tributaries in the state of Rhode Island and this commonwealth, with power to make recommendations to the legislative departments of said state and this commonwealth relative to legislation deemed by it necessary or proper to accomplish any or all of such purposes, to recomend to the governing bodies of the several municipalities within said watersheds in said state and this commonwealth any matter or thing which the authority believes will be conducive to the health,welfare or safety of said inhabitants, and to make rules and regulations within the scope of its powers and duties. The authority shall annually on or before December thirty-first make a report in writing to the governor of the state of Rhode Island, to the governor of this commonwealth and to the New England Regional Planning Commission of the National Resources Board of the federal government.

SECTION 15. The provisions of this act, except the provisions of section fourteen and the provisions of section two other than those which provide for the management and control of the district by the board, shall cease to be effective on January first, nineteen hundred and thirty-seven, unless prior thereto at least three hundred thousand dollars has been allocated by the federal government, under authority of appropriate federal legislation, for any or all of the purposes of this act.

SECTION 16. This act shall take effect upon its passage.

Approved April 30, 1936

CHAPTER 410 OF THE ACTS OF 1936

AN ACT providing that the Blackstone River Valley District shall pay certain costs in connection with projects constructed by it.

Be it enacted, etc., as follows:

SECTION 1. Chapter two hundred and forty-eight of the acts of the current year is hereby amended by striking out section four and inserting in place thereof the following:--

SECTION 4. The board may appoint and may at pleasure remove a treasurer and a clerk, who need not be members of the board, and both offices, if the board deems it advisable, may be held by the same person. The treasurer shall give to the board a bond payable to the district with a surety company authorized to transact business in the commonwealth and satisfactory to the board as surety, in such sum as the board may prescribe and conditioned on the faithful performance of his duties. The clerk shall take oath to faithfully and impartially perform his duties. The duties of the treasurer and the clerk shall be those usually appertaining to said offices, respectively, and in addition such as may from time to time be prescribed by the board. The compensation of the treasurer and of the clerk shall be determined by the board. The board may also appoint and determine the compensation of, and may at pleasure remove, a chief engineer, who shall direct the engineering work, and act as executive manager of the district. (The compensation of persons appointed under authority of this section, and land damages if authorized as hereinafter provided, together with other expenses authorized by this act and not chargeable to the federal government, shall be paid by the municipalities of the district, except Millville, and shall be considered as a part of the expense of maintenance of the district.)

The board shall secure convenient quarters for an office and for the keeping of maps, plans, documents and other papers relating to the business of the board. It shall at all times keep full and accurate accounts of its receipts, expenditures, disbursements, assets and liabilities, and shall annually on or before December thirty-first make a written report to the governor and council.

SECTION 2. Section nine of said chapter two hundred and forty-eight is hereby amended by inserting in the second line, after the word "may", the following:-- if authorized as hereinafter provided, -- so as to read as follows: -- Section 9. For any purpose authorized by this act the board, acting on behalf of the district, may, if authorized as herein fter provided, take by eminent domain under chapter seventy-nine of the General Laws, or

acquire by purchase or otherwise, such lands, water courses, rights of way or other easements property and rights therein as it may deem necessary. Any person,corporation or municipality whose property has been taken or injured by any action of the board under authority of this act may recover from the district under the provisions of said chapter seventy-nine such damages therefor as he or it may be entitled to. The board may sell at public auction any property, including land, acquired by it hereunder and in its opinion no longer needed in the performance of the powers and duties conferred and imposed upon it by this act, and may from time to time lease any property in its opinion not then needed by it for the purposes of this act. The board may enter upon any lands or waters for the purpose of making surveys, test pits and borings,and may take by eminent domain under said chapter seventy-nine or acquire by purchase or otherwise the right to temporarily occupy any lands necessary for the carrying out of any of said purposes.

SECTION 3. Said section nine of said chapter two hundred and forty-eight is hereby further amended by adding at the end the following new paragraph:--

*(In the event that the board deems it necessary, in connection with any project authorized hereunder, to purchase or to take by eminent domain, any lands, water courses, rights of way or other easements, property or rights therein, the board shall in writing notify the board of slectment of each town, and the mayor of each city, in the district, and if a majority of said boards and mayors approve in writing such purchase or taking then the board may make such taking or may so purchase in the name and on behalf of the district. For the purpose of this paragraph each board of selectmen and each mayor shall have one vote.)

SECTION 4. Section eleven of said chapter two hundred and forty-eight is hereby amended by inserting after the word "act" in the eight line words: --, including any land damages and costs of purchase authorized as hercinbefore provided,-- so as to read as follows:--

SECTION 11. Annually before January first the board, on behalf of the district, shall certify to the assessors of each municipality within the district, except Millville, the sum constituting the share of such municipality of the estimated cost for the ensuing year, over and above receipts of the district, of the maintenance and operation of the works maintained and operated by the board under authority of this act, including any land damages and costs of purchase authorized as hereinbefore provided, and also the share of such municipality of any deficit for the then current or any preceding year; and the amount so certified shall be raised by the assessors of such municipality during said ensuing year and shall be paid, not later than November first, into the treasury of the district. Each such municipality, except Millville, shall be annually assessed hereunder such proportion of such cost of main-

tenance and operation as the board shall determine, based upon the proper proportion of such municipality of the benefit derived by it from the works, so maintained and operated hereunder. If any municipality is aggrieved by an assessment made upon it hereunder, the respective amounts to be paid by the municipalities of the district, except Millville, shall be determined by three commissioners to be appointed by the supreme judicial court upon the application of such aggrieved municipality and after notice to the other municipalities of the district. The award of said commissioners when accepted by said court shall be binding upon the municipalities of the district.

SECTION 5. Said chapter two hundred and forty-eight is hereby further amended by striking out section twelve and inserting in place thereof the following:--

SECTION 12. For the purposes of paying the expenses of the construction of the work hereinbefore authorized, the district is hereby empowered to receive from the federal government all sums of money allocated by it for any or all of the purposes of this act, but the board shall have no right to levy upon, or to charge or collect against, any municipality in the district any portion of the cost of such construction. All expenses of construction, including in said term all costs of plans and surveys, and other necessary items of construction, but excluding compensation authorized by section four and land damages, shall be paid for exclusively out of such federal funds so allocated.

Upon the completion of any of such works, the district shall thereafter bear the entire expense of the operation and maintenance thereof.

SECTION 6. This act shall take effect upon its passage.

Approved June 24, 1936

STATE OF RHODE ISLAND, &r.

IN GENERAL ASSEMBLY

799 CHAP. 2346

January Session, A.D. 1936

AN ACT TO PROVIDE FOR THE ESTABLISHMENT OF A BOARD TO ACT JOINTLY WITH MASSACHUSETTS AUTHORITIES AS AN AUTHORITY TO BE KNOWN AS THE BLACKSTONE VALLEY AUTHORITY.

(Approved May 2, 1936)

It is enacted by the General Assembly as follows:

SECTION 1. There is hereby established a board to be known as the Blackston Valley Board, to be known hereinafter as the Board, to act in co-operation with the authorities of the Commonwealth of Massachusetts, for the purposes of advancing rehabilitation of the valley as hereinafter defined and administrating such grants as may hereafter be made by the federal government for the payment of the expense of construction of such projects as may be deemed to be advisable for the conservation of health, for the improvement of sanitation, for the abatement of nuisances, for the elimination of soil erosion, for stream regulations and flood control, for reforestation, for the co-ordination and development of transportation, housing and recreation facilities, and for such improvements as may be found reasonably necessary and proper for the health, welfare and safety of the inhabitants of the watersheds of the Blackstone and Seekonk Rivers, and their tributaries in Massachusetts and Rhode Island.

SECTION 2. Said board shall consist of five members, to be appointed by the governor for such terms as he may see fit and at such salaries as may be established by him, if and when such grants become available.

SECTION 3. Said board shall act jointly with a similar board of the State of Massachusetts and the two bodies so acting shall be known as the Blackstone Valley Authority, to be hereinafter designated as the Authority. The Authority shall prescribe rules for its procedure and official acts.

SECTION 4. The Authority shall provide for the construction and for the subsequent maintenance and operation of the constructed works by making contracts or agreements with the federal government, with the Commonwealth of Massachusetts or State of Rhode Island or political subdivisions thereof, or with any duly, legally and responsibly constituted districts or agencies, or firms,

the approval of the federal government first having been obtained where disbursements of federal funds are involved.

SECTION 5. The Authority shall report annually to the federal government and to the governors of Massachusetts and Rhode Island and shall make recommendations for the continuance and improvement of benefits contemplated under this act.

SECTION 6. The sum of two thousand dollars, or so much thereof as may be necessary is hereby appropriated out of any money in the treasury not otherwise appropriated, for expenditure on or before June 30, 1936, to pay the necessary expenses incurred by the Blackstone Valley Board in carrying out the provisions of this act and for preparing and assembling plans, reports, estimates and application for federal funds; and the state comptroller is hereby directed to draw his orders upon the general treasurer for the payment of said sum, or so much thereof as may from time to time be required, upon receipt by him of proper vouchers approved by two members designated by the Blackstone Valley Board.

"Notwithstanding the provisions of clause 1 of section 12 of chapter 2250 of public laws, 1935, any unexpended balance of said appropriation shall be available for the next fiscal year."

SECTION 7. The board shall have the functions of the Authority within the State of Rhode Island until the Authority is established.

SECTION 8. This act shall take effect upon its passage, and all acts and parts of acts inconsistent are hereby repealed.

## APPENDIX B

## HISTORY OF BLACKSTONE CANAL

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The project of opening a navigable communication from the waters of Narragansett Bay in Rhode Island to the center of Massachusetts, through the valley of the Blackstone, first engaged public attention in 1796. The author and patron of one of the earliest attempts to connect the interior with the seaboard by water highway was the late John Brown of Providence.

A petition was presented at the May session of the General Court of the Commonwealth in 1796. At the same time a counter plan which had the effect, if not the intent, of defeating the former, was started, of constructing a canal from Boston to the Connecticut River. One of the projected waterways was from Boston via Fitchburg, to Winchendon and the Millers River valley. Application for the Providence Canal was refused,and the projectors were obliged to abandon the undertaking. Surveys were soon after made for the Massachusetts Canal, and with their conclusion, terminated the exertions of the subscribers.

For a quarter of a century the matter of the Blackstone Canal lay untouched. While the embargoes of 1809, and after, ruined New England's reputation for shipping, during the period following the war of 1812 commercial relations righted themselves. Many mills were built on the Blackstone which added greatly to the value of the land, and caused an eventual expense in construction which would not have existed if the project had been executed when first proposed. For instance, had the mills not been built first along this river they could not have acquired any water rights, as the canal would have acquired them all, and, if the mills had not been built, Worcester probably would have been a much larger city, and all the towns along the river would not have been built at all.

In 1822 the plan was revived and subscriptions opened for a survey, which was completed in October of the same year. Acts of incorporation were obtained for distinct companies in each state, subsequently united July 5, 1825, under the name of the "Blackstone Canal Company".

The cost of this canal was estimated at $500,000., but it cost over $700,000. Although the first $500,000. worth of stock was very much sought after, they had some trouble marketing the remainder.

In 1824 the excavation was commenced in Rhode Island. In August, 1825 prospective damage to be done by raising the level of certain ponds was appraised. The following ponds were under consideration:

Ramshorn Pond in West Millbury. This is at least fifteen miles from the Blackstone Canal. Dorothy Pond, located on Dorothy Brook in East Millbury. North Brook in Worcester, at the head of one of the Blackstone River branches. Bad Luck Pond and Manchaug Pond, located in Douglas, at least seven miles from the canal,were others mentioned. These ponds were going to be used for storage of water needed in the dry season. In 1826 the first earth was removed in Massachusetts, near Thomas Street, Worcester.

The Canal was 45 miles long, four feet deep and 45 feet wide. At Worcester it was 451 feet above tide level at Providence, and had about 62 locks made of hewn stone at a cost of $4,000. apiece. Remains of these locks are to be found in many places. There is one just south of Millville; another near the Uxbridge-Northbridge line. The Canal is used today in many places as the tailrace or canal to many mills. Near Saundersville the canal is north of Saundersville Mfg. Co., and about 25 feet above the present river. The Canal was built along the shores of the Blackstone River until it arrived at a point near Lonsdale, Rhode Island. Here the engineers built nine locks to lower the packets from the Blackstone River to the Moshassuck River,a difference of 25 feet in elevation. The Canal was then constructed along the Moshassuck River for a distance of about seven or eight miles to Providence. Today the trail of the old canal is a faint one that may be seen along the Worcester-Providence road, over-grown, for the most part, with underbrush and weeds.

The Blackstone Canal afforded facilities for passenger and freight transportation. The Canal was opened for navigation on July 1, 1828, but not until October 6, 1828, did a boat pass the whole length of the Canal. On this day the packet boat "Lady Carrington" arrived, and her arrival was announced by the firing of a cannon and the ringing of bells. The "Lady Carrington" was a boat of unusual construction, fitted with a covered cabin and other conveniences, and was drawn by two horses, at the rate of four or five miles an hour. The trips north and south were made on alternate days, and the fare was One Dollar.

The freighters were in fleets of flat-bottomed scows about 70 feet long and 9½ feet wide, and were drawn by horses or mules. The rates were estimated at one cent per ton per mile, and the travel was three miles per hour. Coal, iron, cotton, wool, corn, salt, flour, molasses, ore, gypsum, leather and wood were the principal freight carried. The year 1832 showed the greatest amount of freight transported, the tolls amounting to $18,907.45.

There were other reasons for the failure of the Canal aside from the financial elements. It was built nine-tenths of the way and depended on slack water navigation for the remainder, which resulted in boats being stranded and delayed, both from high water and low water, for weeks at a time. The Canal was, in some years,

closed by ice for four or five months. In time of drought water was scarce, even for the levels and locks, which impeded navigation and transportation.

Many suits arose from the question of the preference of use of water. The Canal Company charged that the mill owners withheld water, while the mill owners counter-charged the waste of water. In Rhode Island mill owners, in a few instances, went so far as to put large loads of stone into the locks so as to prevent the operation of the Canal. Had the Canal Company bought the water rights these disputes would have been avoided.

If the Providence & Worcester Railway had not been given a charter on March 12, 1844, by the Rhode Island Legislature, the Canal might now be still in use. This railroad parallels the canal, and as it did not have to wait for water in dry times, or for ice to break up in the spring of the year, it soon took all the trade away from the Canal. The last toll was collected on the Canal November 9, 1848, the water rights were disposed of, and, as one stockholder at a meeting of the Railway Company said, "The canal is weak as water, and the railroad strong as iron."

Although the canal was not a paying proposition, it did aid the towns and mills, as it pointed out a way to store water for their use when needed, and the mills were benefited by the dams. As a matter of fact, the Blackstone Canal was always of more value to the public than to its stockholders. The former had the advantages resulting from the reservoirs which had been built along the route to hold back the spring water. More water flowed, and increased hydraulic power encouraged the building of many manufacturing plants.

The Canal was abandoned in 1849 when its charter was revoked on completion of the Providence-Worcester Railway. The charter granted to the Railway required the abandonment of the Canal and the restoration of water rights by removal of locks that changed the water levels.

Note:- The foregoing excerpts were taken from "History of Worcester County", histories of different Towns along the River, pamphlets and clippings, and "History of State of Rhode Island and Providence Plantation".

APPENDIX C

STRUCTURES SUBJECT TO INUNDATION - MARCH, 1936 FLOOD

(AN ANALYSIS OF TABLE 14)

Public Buildings

Blackstone:

In the town of Blackstone there were two (2) Public Buildings damaged by flood water. These buildings were the Blackstone Town Hall and the Blackstone Court House. The damage to both of these buildings was to stock and not to the structure. These buildings are also in the flood plain.

| | |
|---|---|
| Damage to Town Hall ..... | $1,500. |
| Damage to Court House ..... | 1,000. |
| Grand Total for Blackstone..... | 2,500. |

Worcester:

The City of Worcester suffered damage to sixteen (16) buildings, all Public. Eleven (11) of these were in the flood plain while the remaining five (5) were in the area of the upper tributaries, where overflow or runoff caused damage.

The following text will give the names of the buildings; the cause and the extent of damage:

| | Name of Building | Flood Plain | Damage | Cause and other Remarks |
|---|---|---|---|---|
| 1 | Webster Street School | Yes | $2,000. | Flood Basement No building damage |
| 2 | Webster Street Fire House | Yes | 6,200. | Flood Basement Yard erosion Undermining wall |
| 3 | Columbus Park School | Yes | 600. | Basement flooded Stock damage |
| 4 | Lamartine Street #1 | Yes | 800. | Basement flooded Yard erosion |
| 5 | Cambridge, Street #2 | Yes | 1,500 | Basement flooded Damage to stock Drains blocked by silt |
| 6 | Webster Square School | Yes | 2,000 | Basement flooded Yard erosion. Boiler room flooded basement |
| 7 | Webster Square Fire House | Yes | 2,500. | Equipment. Wash Ground building |
| 8 | Prov. Street Junior High School | No In area of quick shed | 4,500. | Boiler room flooded, soil erosion, painting. Equipment on premises at the time, damages. Drain pipes blocked and had to be replaced. Basement flooded, some stock. |
| 9 | Heard Street School | Yes | 300. | |
| 10 | North High School | Yes | 4,500. | Boiler room flooded erosion and stock |
| 11 | Trowbridge School | No | 500. | Erosion to yard |
| 12 | Tatnuck School | No | 700. | Erosion to yard |
| 13 | Mulcahy-Field | Yes | 500. | Flooded by water and badly silted. |
| 14 | Indial Hill School | Yes | 1,200. | Yard badly washed out and silted |
| 15 | Edgeworth St. School | No | 400 | Yard washed out. |
| 16 | May Street School | No | 1,400. | Yard badly washed and guttered. |

Addenda:

Water damage to plaster and paint of these buildings not assigned to any particular building, but lumped for all $ 1,800.00

Grand total for Worcester $31,400.00

## Industrial Buildings

Industrial buildings that were damaged by the March, 1936, flood, and showing loss of stock, property, supplies, machinery, manufactured goods, apparatus, coal, etc., will follow,and an itemized list of its factories will be shown:

In the City of Worcester twenty-seven (27) factories were affected, and all are in the flood plain.

A. Worcester ..... 26

| | | | |
|---|---|---|---|
| 1. | Wickwire-Spencer Co. - Merchandise | | $30,000.00 |
| 2. | Mort Printery - Loss of equipment | | 1,800.00 |
| 3. | Mulcahy's Cafe - Merchandise | | 200.00 |
| 4. | Parisian Candy Shop - Merchandise | | 800.00 |
| 5. | J. J. Gibbons - Merchandise | | 100.00 |
| 6. | First National Stores - Merchandise | $3,000.00 | |
| | Property | 900.00 | |
| | Debris (Cleanup) | 100.00 | 4,000.00 |
| 7. | Webster Square Pharmacy - Merchandise | 500.00 | |
| | Cleaning up | 100.00 | 600.00 |
| 8. | Webster Market - Merchandise | | 200.00 |
| 9. | Webster Sq. Bowling Alleys - Property | | 6,000.00 |
| 10. | Hardy Machine Co. - Merchandise | | 9,000.00 |
| 11. | Webster Sq. Gasoline and Business, Property and Stock | | 1,210.00 |
| 12. | American Steel & Wire Co. - Property, (No. and So. Works damage) Stock and Machinery | | 125,000.00 |
| 13. | Whittall Rug Co. - Property and Machine | | 62,000.00 |
| 14. | The Norton Co. - Property | | 500.00 |
| 15. | Loring Coes Co. - Property | | 5,400.00 |
| 16. | G. F. Wright Steel Co. - Property | | 12,000.00 |
| 17. | W. E. Aubuchon Co. - Merchandise | | 475.00 |
| 18. | C. E. Foster - Merchandise | | 200.00 |
| 19. | St. John's Ice Cream Parlor - stock | | 200.00 |
| 20. | Community Drain Co. - Merchandise | | 2,050.00 |
| 21. | Webster Square Laundry - Property and Merchandise | | 2,175.00 |
| 22. | Webster Blacksmith Shop - Merchandise | | 100.00 |
| 23. | Barrows Hardware Store - Merchandise | $6,000.00 | |
| | Automobile | 500.00 | 6,500.00 |
| 24. | Geo. Duffy Mfg. Co. - Property and Machinery | | 100,000.00 |
| 25. | Worcester Fabric Corp. - Property and Machinery | 2,500.00 | |
| | Merchandise | 500.00 | 3,000.00 |
| 26. | Worcester Consol. Ry. - Machinery, Stock and Property | | 6,000.00 |

B. Grafton ..... 1

| | | |
|---|---|---|
| 1. | Saunders Cotton Mill - Stock | 3,000.00 |

C. Millbury ..... 4

| | | | |
|---|---|---|---|
| 1. | Watson-William Mfg. Co. - Stock | $7,000.00 | |
| | Property | 3,000.00 | 10,000.00 |
| 2. | Felters Co. - Materials | 3,700.00 | |
| | Manufactured Goods | 2,418.00 | |
| | Supplies | 388.00 | |
| | Machinery | 1,558.00 | 8,064.00 |
| 3. | Millbury Machine Co. - Pumping and supporting building | | 1,000.00 |
| 4. | S. E. Hull Co. - Merchandise (owned by clients) | | 11,000.00 |

D. Northbridge ..... 4

| | | | |
|---|---|---|---|
| 1. | Whitin Machine Works - Machinery | $12,000.00 | |
| | Coal | 900.00 | |
| | Apparatus | 10,000.00 | |
| | Merchandise | 15,000.00 | 37,900.00 |
| 2. | Paul Whitin Mfg. Co. - Merchandise | | 3,000.00 |
| 3. | Kupfer Bros. Paper Co. - Merchandise | 15,000.00 | |
| | Building | 8,500.00 | 23,500.00 |
| 4. | Three Stores - Merchandise | 800.00 | |
| | Debris | 400.00 | 1,200.00 |

E. Sutton ..... 1

| | | | |
|---|---|---|---|
| 1. | B. Cohen & Sons - Property | 31,500.00 | |
| | Merchandise | 44,200.00 | 75,700.00 |

F. Uxbridge ..... 2

| | | |
|---|---|---|
| 1. | Hecla Mill - Buildings | 14,500.00 |
| 2. | Uxbridge Worsted Co. - Property | 500.00 |

G. Leicester ..... 1

| | | | |
|---|---|---|---|
| 1. | River Woolens, Inc. - Merchandise | 10,000.00 | |
| | Machinery | 2,000.00 | |
| | Property | 15,000.00 | |
| | Reclaiming stock | 2,000.00 | 29,000.00 |

## Houses

Private Houses were also greatly affected by flood, and a list of the amounts of damage and numbers of houses and their locations follow:

A. Worcester - Forty-seven (47) houses. These houses are all located within the flood plain.

(a) Webster Square section, underpinning damaged and cellars flooded, affecting seventeen (17) houses and at a cost of $900.00.
(b) Brosnahan Square section, underpinning damaged and cellars flooded, affecting three (3) houses and costing $100.00.

B. Douglas - Seven (7) houses, all in the flood plain.

(a) Gilboa Street section, underpinning and walls damaged and flooded cellars, affecting seven (7) houses and costing $3,100.00.

C. Grafton - Nine (9) houses, all in the flood plain.

(a) North of Wuskunut Mills section, underpinning and flooded cellars, affecting nine (9) houses and costing $1,400.00.

D. Millville - Ten (10) houses, all in the limits of the flood plain.

(a) Main Street section, underpinning, a wall and flooded cellars, affecting ten (10) houses and costing $2,000.00.

E. Northbridge - Forty (40) houses, all within the limits of the flood plain.

(a) Linwood Avenue section, walls torn out, underpinning gone, flooded cellars, affecting forty (40) houses and costing $2,000.00.

F. W. Upton - Three (3) houses, all within the limits of the flood plain.

(a) West Main Street section, walls out, flooded cellars, affecting three (3) houses and costing $200.00.

G. Uxbridge - Forty (40) houses, all within the limits of the flood plain.

(a) Mendon Street section, flooded cellars, affecting five (5) houses, costing $250.00.
(b) Hartford Avenue section, flooded cellars, walls damaged, affecting thirty-five (35) houses and costing $1,750.00

H. Millbury - Three houses (3) all in the flood plain.

(a) Canal Street section, flooded cellars, affecting two (2) houses and costing $150.00.
(b) Elm Street section, flooded cellar, wrecked foundation and total damage to foundation. This affected one (1) house and cost $1,850.00.

I. Blackstone - Forty-seven (47) houses, all in the flood plain.

(a) St. Paul Street section, flooded cellars and underpinning damaged, affecting twenty-five (25) houses and costing $1,350.00.
(b) Canal Street section, flooded cellars and some foundation damage, affecting twenty-two (22) houses and costing $1,000.00.

APPENDIX D

STREAM POLLUTION AND WASTE DISPOSAL CONDITIONS

The following is a summary of the existing sanitary conditions within the towns of the valley, as condensed from the Report on "Sources of Pollution of the Blackstone River Valley" prepared by the W.P.A. State Planning Projects.

Town of Boylston

Only the southwesterly portion of the town is located in the watershed. It is not thickly populated and has no industrial activity. Pollution may be considered negligible.

Town of West Boylston

A very small section of the southern part of the town is located in the watershed. Pollution in this area may be considered negligible.

Towns of Holden and Paxton

Only small sections of these towns are located in the watershed. The portions of those towns are watershed areas for the Worcester Water Supply; are well policed and all sources of pollution in this area may be considered negligible.

Town of Leicester

The easterly portion of the town is located in the watershed. No public sewage system exists, and the disposal of sanitary sewage is left to the discretion of each individual resident. Kettle Brook, below the Worcester Reservoir No. 1, is polluted to a high degree by both sanitary sewage and industrial waste. There are approximately 25 sink drains which discharge into this brook, in addition to the 22 individual outlets which discharge sanitary sewage. Sources of pollution also originate in this section of the town from privies, septic tanks and cesspools located within the area. Garbage and rubbish dumps are also located at the edge of the stream, and add to its unsanitary condition. The industrial waste from a woolen mill is discharged into Kettle Brook and creates an unsanitary condition. The combination of domestic sewage and industrial waste discharged into Kettle Brook within this area creates an undesirable and unsanitary condition, and during low water periods disagreeable odors are discernible.

Town of Auburn

The town is located in the northwestern section of the water-

shed. The town has no public sewage system and the methods of sewage disposal consist of cesspools, septic tanks and privies. Kettle Brook receives sanitary sewage pollution from two sewer outlets located in the Stoneville section. One of these outlets discharges sink drainage from 19 houses, and the other discharges the overflow from the cesspool from a single house. Other sources of pollution have been created by garbage dumps, privies and cesspools located near the edge of the stream. Industrial wastes from a woolen mill and a rendering plant are also discharged into Kettle Brook.

Ramshorn Brook receives the sink drainage from two houses and also the effluent from a treatment plant which is used for the purification of the sewage from 250 students. Sources of pollution are also created by privies located within 150 feet of the brook. Industrial waste from a woolen mill is also discharged into Ramshorn Brook, which creates an unsanitary condition. Although the sanitary conditions of the brook are not extremely offensive, they could be greatly improved.

City of Worcester

The city is located in the northerly section of the watershed. The city has a modern sewerage system and purification plant for the complete treatment of sewage. Within the city a large amount of industrial waste is discharged into the streams. The most offensive are discharged from the gas plant and the wire mills. The highest degree of pollution of the Blackstone River is, without doubt, located at South Worcester below the wire mills. In addition, industrial wastes from four woolen mills and other types of industrial plants are discharged.

The Millbrook Channel, which joins Middle River in South Worcester, is polluted from the discharge of both industrial and domestic waste. In addition, a large number of combined sewers discharge into this channel at times of heavy runoff.

A portion of Lake Quinsigamond is located in the city. This section of Worcester located near the lake has no public sewerage system. There are a large number of summer cottages located within this area, and the disposal of sanitary sewage is by means of cesspools, septic tanks and privies. Very unsanitary conditions have been created due to improper methods of sewage disposal. At times of heavy runoff Lake Quinsigamond also receives the discharge of combined storm water and sanitary sewage from by-passes at the Belmont Street bridge.

Town of Millbury

The town has no public sewerage system; disposal is by means of privies, cesspools and private sewers. Ramshorn Brook is polluted by the discharge of industrial waste from a wool scouring plant and the seepage from cesspools and septic tanks. Singletary Brook

is highly polluted in its course from its origin to its junction within the Blackstone River by the large amount of industrial wastes discharged into it from industrial plants located on its banks. Dorothy Brook is in fairly good condition since it receives no direct discharge of either sanitary sewage or industrial waste, but there are 27 privies on the shores of Dorothy Pond, which is the origin of Dorothy Brook.

The sanitary conditions along the Blackstone River here are very disagreeable and offensive. There are 26 private sewers which discharge domestic sewage from approximately 835 persons. In most cases these outlets discharge on the bank of the stream and sludge deposits may be found at nearly every outlet. In addition to the large amount of sanitary sewage there is a large amount of industrial waste discharged from woolen mills located on its banks.

The combination of both domestic sewage and industrial waste has created a very unsanitary and offensive condition within the town. In fact, the conditions within the town of Millbury are probably more unsanitary than in any town in the Blackstone Valley.

Town of Sutton

This town is located in the west central portion of the watershed. There is no public sewerage system in this town and sewage is disposed of by means of privies, cesspools, septic tanks and private sewers. The sources of pollution of Cold Spring Brook consist of privies used by approximately 20 persons located within 200 feet of the water's edge, and also the discharge of industrial waste from a laundry, and the domestic sewage from an industrial plant.

The Mumford River receives the discharge from two private sewers, one of which discharges the sewage of 19 persons; the other discharges the sink drainage from two houses. The seepage from a large cesspool which receives the sanitary sewage from approximately 25 persons is another serious source of pollution. The industrial waste from a shoddy mill is also discharged into the Mumford River.

Near the village of Wilkinsonville sanitary sewage from approximately 75 persons is discharged through a private sewer. The accumulation of sewage at the outlet is unsightly and unsanitary, and gives rise to extremely disagreeable odors. Approximately 13 privies are located within 75 feet of the shore of Singletary Lake. However, all of them are in good condition and they are not dangerous sources of pollution.

The sources of pollution of Manchaug Lake and Stevens Pond consist of approximately 35 privies which are located within 100 feet of the water's edge. There is also a large amount of rubbish and debris dumped on the shores, which is both unsanitary and unsightly.

Town of Shrewsbury

The town is located in the northeastern section of the watershed, and the greater portion of Lake Quinsigamond is located within it. This section of Lake Quinsigamond is used very extensively for recreation purposes, and as there is no sewerage system in this part of the town sewage is disposed of by means of cesspools, septic tanks and privies. A total of 475 cesspools, septic tanks and privies border the lake. In a few cases sink drainage is discharged directly on the surface of the ground or into the Lake. Five large garbage waste dumps border the lake, the drainage from which results in pollution and unpleasant odors.

Since this section of the lake is used to such a great extent for bathing and other recreational purposes, new methods of sewage disposal should be installed to eliminate these sources of pollution.

Town of Westboro

Only a small section of the town is located in the watershed, and since there are no streams tributary to the Blackstone River the pollution problem is negligible.

Town of Grafton

This town, which is located in the northeasterly section of the watershed, has no public sewerage system. In North Grafton there are five privies used by approximately 25 persons, located within 200 feet of Quinsigamond River. The effluent from the sewage treatment plant at the Grafton State Hospital, containing approximately 1900 persons, is discharged into a small brook which is tributary to Goddard Pond. There are also 27 privies located on the shores of the pond which are used by approximately 108 persons, and seepage from them into the pond is evident.

The West River has as sources of pollution seven privies within 100 feet of the stream, but as these are scattered the sources of pollution may be considered negligible.

In the village of Saundersville the sources of pollution consist of nine sink drains which, together with the overflow from four cesspools, discharge through a 4-inch pipe directly into the river. In the village 21 privies are located within 100 feet of the water's edge.

In the village of Fisherville a large number of cesspools are located near the bank of the river, but the exact number is not known. The overflow pipes from four cesspools discharge into the stream, and seepage from 21 privies located within 100 feet of the water's edge is very evident. In addition to these sources of pollution the domestic sewage from 500 employees of a cotton mill is

discharged directly into the river.

The sanitary sewage from the Wuskanut Mills in the village of Farnumsville, together with that of five mill houses, is discharged through a septic tank into the Blackstone River. The sewage from ten mill houses in the village is discharged onto a small sand filter. However, it is in such poor condition, and its efficiency so low, that the effluent is still very offensive. Nineteen privies are located in the village, but conditions around these are very unsatisfactory and sometimes offensive.

In addition to the domestic sewage untreated industrial waste from a large woolen mill is discharged into the river, creating an offensive condition.

Town of Oxford

A small section of the town is located in the watershed, but there is no industrial activity within this area, and the sources of pollution from sanitary sewage may be considered negligible.

Town of Douglas

This town, located in the extreme southwesterly section of the watershed, has no public sewerage system; disposal is by means of cesspools, septic tanks and private sewers. The chief sources of pollution originate in the village of East Douglas from a private sewer serving approximately 100 people. The outlets discharging into the Mumford River are in a very unsanitary condition due to the accumulation of sludge on the banks of the river. In addition, the discharge of industrial waste into the stream from the two large woolen mills makes the condition of the river very objectionable.

Town of Northbridge

The town, located in the east central section of the watershed, has a modern complete treatment sewerage system which also serves Linwood, Whitinsville and Rockdale. The type of treatment at this plant is plain sedimentation followed by sand filters. There are no apparent sources of sanitary pollution and only small amounts of industrial wastes are discharged.

In the village of Riverdale privies and cesspools are used, but some seepage enters the river. In the village of Rockdale there are five privies within 100 feet of the river. Small amounts of industrial waste from a paper mill and a textile mill are discharged.

Town of Hopkinton

Only a small section of the town is located in the watershed. North Pond, a large portion of which is located in the town, is

used for recreational purposes, with approximately 107 cottages located on it. The only method of sewage disposal is by privies, the greater portion of which are located within 100 feet of the water's edge, causing some pollution of the water. There is no industrial activity in the area.

Town of Upton

The town is located in the east central portion of the watershed. The village of West Upton has a sewerage system and purification plant for the partial treatment of sewage. The sewage from approximately 40 families and one-half the industrial waste from a hat factory located in the village is discharged into the sewerage system and receives partial treatment. Important sources of pollution of the West River are the effluent from a settling basin which receives the sanitary sewage from six houses located in the village, a large cesspool located within 20 feet of the water's edge serving 23 people, and the sewage from nine persons which is discharged directly into the river. Wildwood Lake, located in the town, is polluted by seepage from 20 privies and three cesspools within 50 feet of the high water mark and serving about 80 people. The sources of pollution of Warren Brook are so scattered that they may be considered negligible, with the exception of a few dumps located near the junction of Warren Brook and West River. The sources of pollution of Center Brook consist of four privies located within 50 feet of the water's edge and the sink drainage from five families which is discharged directly into the water. A garbage dump on the bank of the stream is also a dangerous source of pollution.

Some pollution originates from approximately 50 privies on North Pond which are within 100 feet of the shore.

Town of Uxbridge

The town is located in the south central section of the watershed. It has no sewerage system and sanitary sewage disposal is by means of cesspools, septic tanks, privies and in some cases private sewers which discharge directly into the stream. The Mumford River is the most highly polluted. It receives the sanitary sewage from five private sewer lines, serving approximately 540 persons. In the village of North Uxbridge seven individual outlets and 17 sink drains discharge into the river. Fourteen privies are located within 100 feet of the water's edge, most of which are in a very bad condition. In addition to the sanitary sewage the Mumford River receives a large amount of objectionable industrial waste from a woolen mill.

The sources of pollution on the Blackstone River consist of seven privies, located within 100 feet of the water's edge and used by approximately 50 persons, and in addition to this the discharge of industrial wastes from two woolen mills.

The sanitary sewage pollution of the West River may be considered negligible, however, it does receive the industrial waste from two large woolen mills located in Uxbridge Center.

Town of Millville

The town, located in the southeasterly section of the watershed, has no public water supply nor sewerage system. Privies are used in most cases for the disposal of sanitary sewage.

A survey of the banks of the Blackstone River indicated that the sources of pollution originating from privies in this town were not serious; however, in a good many cases these privies are located so close to the water supply sources that the situation is both alarming and dangerous to public health. Another dangerous source of pollution originates from the discharge of sanitary sewage into a storm drain near the center of the town. This storm drain, open in some sections and flowing through flat ground, creates very unsatisfactory conditions during dry weather when the sewage is not quickly carried away. At present no industrial plants are in operation.

Town of Blackstone

The town, located in the southeastern section of the watershed, has no public sewerage system and the disposal of sewage consists of privies and cesspools. In some cases, however, domestic sewage is discharged through private sewer lines to a convenient outlet.

There are three main outlets through which sanitary sewage is discharged; one from the Blackstone High School; another from the town hall and courthouse, and the third, sink drainage and sewage from 16 houses.

Twenty-two individual sewer lines discharge sanitary sewage and sink drainage. There are also 48 privies within the town located within 300 feet of the water's edge, nine of which are directly built on the bank. Six cesspools are also located within 100 feet of the water's edge, all of which are in very poor condition, and from which seepage is evident. The general sanitary conditions around both the sewer outlets and the privies are very objectionable.

The sources of sanitary sewer pollution of the Mill River are located at Harris Pond, where seepage is evident from 15 privies and 10 cesspools located within 100 feet of the stream.

No industrial plants are operating at the present time.

Town of Hopedale

The town, located on the Mill River in the southeasterly section of the watershed, is equipped with a sewerage system and treatment plant for the complete treatment of sewage. The treatment consists of septic tanks and sand beds, which are in good condition, and a high degree of treatment is obtained. With the exception of the discharge of the effluent from the sewerage treatment plant, there are no other visible sources of pollution. A small amount of industrial waste is discharged into the Mill River from an industrial plant which manufactures shuttles.

Town of Mendon

The town, located on the Mill River, lies in the southeasterly section of the watershed. Three small brooks, all tributary streams of the Blackstone watershed, are located in this town. Sanitary pollution of the Mill River is negligible, but it does receive some woolen wastes. Nipmuck Pond, the origin of Mendon Brook, is used extensively for recreational purposes. On its shores there are some 65 cesspools and 45 privies, a greater portion of which are within 75 feet of the water's edge, and all within 200 feet. Most of the cesspools are in good condition, but seepage from privies in this locality is evident in a large number of cases.

Town of Milford

Only a small section of the town lies in the watershed. A portion of North Pond is located in the town, and the Mill River forms a boundary line between it and the towns of Mendon and Upton.

Pollution of North Pond originates from 37 privies, all within 100 feet of the stream. Pollution of the Mill River is so scattered that it may be considered negligible.

Town of Bellingham

Only the south portion of the town drained by Peter's River is located in the watershed.

The sources of pollution consist of eight privies located on the shores of Old Hoag Lake, all of which are in poor condition and from which seepage is evident.

Towns of Franklin, Wrentham, Attleboro, North Attleboro and Plainville

Only a small portion of these towns are in the watershed, and sources of pollution may be considered negligible.

APPENDIX E

LIST OF FLOOD CONTROL STUDY MAPS
BLACKSTONE RIVER CHANNEL

1. Plan showing Proposed Kettle Brook Flood By-Pass, Scales 1" = 800' and 1" = 200', by Engr. Dept. City of Worcester, February, 1937.

2. Plan of Junction of Kettle Brook & Half-Way River, Scale 1" = 40' (City of Worcester, Mass.)

3. Proposed Location, Half-Way River and Tatnuck Brook Surface Sewers. Scale 1" = 40' (City of Worcester, Mass.)

4. Sect. V. - Channel Improvements, In Town of Blackstone, near Rhode Island Line, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B1 - Drawing 76.

5. Sect. V. - Channel Improvements, In Town of Blackstone, at Rhode Island Line, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B2 - Drawing 77.

6. Sect. V. - Channel Improvements, In Town of North Smithfield, Rhode Island, at Branch River, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B3 - Drawing 78.

7. Sect. V. - Channel Improvements, In Town of Blackstone, at Blackstone Mfg. Co. Diversion Canal, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B3A - Drawing 79.

8. Sect. V. - Channel Improvements, In Town of Blackstone, near Blackstone Mfg. Co. Dam, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B4 - Drawing 80.

9. Sect. V. - Channel Improvements, In Town of Millville, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B5 - Drawing 81.

10. Sect. V. - Channel Improvements, In Town of Millville, near U.S. Rubber Co. Plant, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B6 - Drawing 82.

11. Sect. V. - Channel Improvements, In Town of Uxbridge, near Millville, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B7 - Drawing 83.

12. Sect. V. - Channel Improvements, In Town of Uxbridge, near Millville, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B8 - Drawing 84.

13. Sect. V. - Channel Improvements, South of Uxbridge Center, Water Resources Map, Scale 1" = 100'. Sheet B9 - Drawing 85.

14. Sect. V. - Channel Improvements, In Town of Uxbridge, at West River, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B10 - Drawing 86.

15. Sect. V. - Channel Improvements, In Town of Uxbridge, at Hecla Mills, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B11 - Drawing 87.

16. Sect. V. - Channel Improvements, In Town of Uxbridge, at Mumford River, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B12 - Drawing 88.

17. Sect. V. - Channel Improvements, In Town of Uxbridge, at Stanley Woolen Mill. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B13 - Drawing 89.

18. Sect. V. - Channel Improvements, In Town of Uxbridge, North of Stanley Woolen Mill. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B14 - Drawing 90.

19. Sect. V. - Channel Improvements, In Town of Uxbridge, near Stanley Woolen Mill Dam. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B15 - Drawing 91.

20. Sect. V. - Channel Improvements, In Town of Uxbridge, North of Stanley Woolen Mill Dam. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B16 - Drawing 92.

21. Sect. V. - Channel Improvements, In Town of Northbridge, Just North of Northern Uxbridge Town Line. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B17 - Drawing 93.

22. Sect. V. - Channel Improvements, In Town of Northbridge, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B18 - Drawing 94.

23. Sect. V. - Channel Improvements, In Town of Northbridge, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B19 - Drawing 95.

24. Sect. V. - Channel Improvements, In Town of Northbridge, South of Church Street, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B20 - Drawing 96.

25. Sect. V. - Channel Improvements, In Town of Northbridge, North of Church Street, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B21 - Drawing 97.

26. Sect. V. - Channel Improvements, In Town of Northbridge, at Kupfer Bros. Mfg. Co. Plant, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B22 - Drawing 98.

27. Sect. V. - Channel Improvements, In Town of Northbridge, North of Kupfer Bros. Mfg. Co. Plant, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B23 - Drawing 99.

28. Sect. V. - Channel Improvements, In Town of Northbridge, at Rockdale, South of Upton Rd., W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B24 - Drawing 100.

29. Sect. V. - Channel Improvements, In Town of Northbridge, at and North of Paul Whitin Mfg. Co. Plant. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B25 - Drawing 101.

30. Sect. V - Channel Improvements, In Town of Northbridge, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B26 - Drawing 102.

31. Sect. V. - Channel Improvements, In Town of Grafton, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B27- Drawing 103.

32. Sect. V. - Channel Improvements, In Town of Grafton, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B28 - Drawing 104.

33. Sect. V. - Channel Improvements, In Town of Grafton, South of School Street, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B29 - Drawing 105.

34. Sect. V. - Channel Improvements, In Town of Grafton, at Fisher Mfg. Co. Plant. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B30 - Drawing 106.

35. Sect. V. - Channel Improvements, In Town of Grafton, North of Fisherville Pond, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B31 - Drawing 107.

36. Sect. V. - Channel Improvement, In Town of Grafton, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B32 - Drawing 108.

37. Sect. V. - Channel Improvements, In Town of Grafton, at Saundersville Mill, W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B33 - Drawing 109.

38. Sect. V. - Channel Improvements, In Town of Sutton, at Anco Mills. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B34 - Drawing 110.

39. Sect. V. - Channel Improvements, In Town of Sutton. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B35 - Drawing 111.

40. Sect. V. - Channel Improvements, In Town of Sutton - Millbury, North of Anco Mills Dam. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B36 - Drawing 112.

41. Sect. V. - Channel Improvements, In Town of Millbury. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B37 - Drawing 113.

42. Sect. V. - Channel Improvements, In Town of Millbury. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B38 - Drawing 114.

43. Sect. V. - Channel Improvements, In Town of Millbury. Near Elm and Main Sts.,W.P.A.Water Resources Map. Scale 1" = 100'. Sheet B39 - Drawing 115.

44. Sect. V. - Channel Improvements, In Town of Millbury. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B40 - Drawing 116.

45. Sect. V. - Channel Improvements, In Town of Millbury. Near Felters Co. Plant. W.P.A.Water Resources Map. Scale 1"= 100'. Sheet B41 - Drawing 117.

46. Sect. V. - Channel Improvements, In Town of Millbury. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B42 - Drawing 118.

47. Sect. V. - Channel Improvements, In Town of Millbury. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B43 - Drawing 119.

48. Sect. V. - Channel Improvements, In Town of Millbury. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B44 - Drawing 120.

49. Sect. V. - Channel Improvements, In City of Worcester. North of Millbury Town Line. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B45 - Drawing 121.

50. Sect. V. - Channel Improvements, In City of Worcester. At Millbury Street. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B46 - Drawing 122.

51. Sect. V. - Channel Improvements, In City of Worcester. At A.S. & W. Co. Plant. W.P.A. Water Resources Map. Scale 1" = 100'. Sheet B47 - Drawing 123.

NOTE: All of the above listed maps are on file with the Massachusetts State Planning Board, State House, Boston, Mass.

APPENDIX F

## I. FLOOD CONTROL RECOMMENDATIONS BY CITY OF WORCESTER

From studies made of the 1936 flood the Engineering Department of the City of Worcester has suggested the following local improvements:

A. The vicinity of Webster Square presents the largest area in need of flood control on our principal streams. Relief in this section may be accomplished by the construction of a conduit, beginning at Leesville Pond at Hope Avenue, and discharging into a swamp bordering on Middle River and to the east of Hope Cemetery. By means of this conduit it would be possible to divert a large part of the flood flows of Kettle Brook from an area of 31.61 square miles of watershed. The by-passing of flood flows from approximately 66 per cent, of the total area contributary to the head of Middle River near Webster Square would do much to correct the undesirable condition existing there. To accomplish this result it would be necessary to construct about 2,000 feet of conduit having a capacity of 2,000 cubic feet per second, together with the necessary head works, and to purchase approximately six acres of swamp land.

B. This back-water condition was undoubtedly a considerable factor in the cause of the damage resulting to this culvert. Thus it is shown that this damage, while far removed from Kettle Brook, may be charged as much, if not more, to Kettle Brook than to Tatnuck Brook, the waters of which flow through this culvert.

This fact serves to illustrate the desirability and rather far reaching effect that the flood diversion of Kettle Brook would have in this area. Such diversion, if provided, would allow the drawing down of Leesville Pond during periods of impending floods, without passing the water through Curtis Pond, thereby permitting Curtis Pond to be drawn down more rapidly.

C. The construction of a relief sewer from Middle River at the South Works of the American Steel&Wire Company to Brosnihan Square would further relieve Mill Brook sewer and prevent flooding of areas immediately north of this point. It is at this point that the Cambridge Street and Quinsigamond Avenue surface water sewers now enter Mill Brook sewer. This sewer would be 4,100 feet in length. If, in the future, the development of the city caused conditions that require relief at points further north this sewer could be extended to afford such relief as was found necessary.

D. It is also possible to divert the flow from the northern section of this watershed by means of a tunnel to Lake Quinsigamond which would be about 11,000 feet in length. The liability of the city for damages resulting from this proposed diversion of waters should be carefully investigated before embarking on a project of this nature. The approximate cost of the foregoing suggested construction is as follows:

| | |
|---|---|
| Improvement of dams for purposes of flood control varies from $1,000. to $10,000. | per dam. |
| Kettle Brook Diversion Conduit | $140,000. |
| Mill Brook Relief Sewer | 500,000. |
| Mill Brook-Lake Quinsigamond Tunnel | 1,300,000. |

Plus damages, if any.

E. Channel Improvements:

1 - Within the City Limits of Worcester

The tributary streams forming the headwater of the Blackstone River converge at Curtis Pond, and the outlet of this pond is the Blackstone River. The major part of this damage within the City of Worcester, due to the flood of 1936, was caused by the overflowing of these tributaries, namely, Tatnuck Brook, Kettle Brook and Middle River.

A detailed report on the condition of the channels of these tributaries, and recommendations for the proper improvements needed, would necessarily extend beyond the present available data, but certain general conditions have been noted and suggestions can be made tending towards corrections as a basis for future study and planning, which can only be properly concluded after complete detailed studies and plans have been made.

From information based on the maps showing the areas affected by flood conditions, and from inspections of the streams and the surrounding territory, the following general recommendations can be made.

Kettle Brook -

The upper part of this stream above Jamesville Pond is through a thickly settled part of the city. Its source is winding and the channel narrow and badly constructed, with the result that there were overflow conditions along its entire length. It is very apparent, however, that these conditions would be entirely overcome by a proper widening, deepening and straightening of the stream bed. All the overflow conditions of this brook through the town of Auburn, back into Worcester through Leesville Pond and into Curtis Reservoir, are due to

bad channel conditions, which could be remedied without much difficulty and after a proper study of alignment and grade.

Overflow from Curtis Pond into Middle River -

At the lower end of Curtis Pond there is a well constructed dam with concrete spillway 75 feet long and earth embankment bulkhead concrete faced. Below the spillway the channel in a distance of 125 feet narrows to 40 feet at the point where it joins Middle River. This junction is at 90 degrees with the flow of Middle River, and is at a point where there is considerable curve in the river. Directly opposite the junction is property of the City of Worcester on which there is a Fire Station.

The alignment of the overflow channel and of the river is such that at present any excess flow over the dam is choked in its passage from the dam, and with the increase of velocity caused by this choking, together with the flow of the river past this junction, an undue accumulation of water is formed along the retaining wall at the Fire Station property. During the flood of 1936 this portion of the Middle River channel was entirely inadequate to pass the volume of water entering from Curtis Pond and Halfway Brook. A large section of the city below this point was inundated, including the Fire Station which had to be abandoned temporarily.

A study of this location indicates that the existing conditions could be remedied by a relocation of the channel walls below the Curtis Pond dam so as to have a uniform width of at least 60 feet between the side walls. A slight change should be made in the alignment of the retaining walls of the city property to eliminate as far as possible the choking that now occurs. A plan has been prepared for a proposed flood by-pass from Leesville Pond, an expansion of Kettle Brook just above Curtis Pond, to Middle River at a point about 500 feet below the junction of the overflow of Curtis Pond and Middle River. This by-pass would lessen considerably the overflow of the Curtis Pond dam, and would relieve the congestion which always occurs at this junction point.

Passing up Halfway Brook and Tatnuck Brook as far as Coes Reservoir the flood survey shows that overflowing occurred along the entire distance. There was little or no flooding of the banks of Coes Reservoir except at the location of the dam where the spillway overflows to continue Tatnuck Brook.

A detailed study of the dam and spillway at Coes Reservoir will be necessary before definite recommendations can be made, but it is very obvious that a system of control waste gates should be installed at this point, and the dam should be raised at least five feet along its entire length. By means of

control gates the present normal level of the reservoir could be maintained, and the additional height of the dam, together with an adequate installation of waste gates, would prevent a recurrence of the bad flood conditions that existed here.

From Coes Reservoir, through Tatnuck Brook and Halfway Brook into Middle River the flood survey indicates that a very serious condition exists, and an inspection shows that alignment is bad and channel capacity and bridge clearance inadequate. A study of the section between Park Avenue and Webster Square has been prepared showing realignment of Halfway Brook which, together with suggested improvements at Curtis Pond and Coes Reservoir, would protect a large section of the City of Worcester from future inundations.

Middle River extends from the confluence of Kettle Brook and Halfway Brook at the foot of Curtis Pond, and becomes the Blackstone River below the dam of the American Steel & Wire Company. Along the entire length of Middle River there was serious overflowing, due mainly to choked stream conditions, bad alignment and inadequate bridge clearances. A study of these conditions will be necessary before proper recommendations can be made for the adequate solution of this problem.

2 - Outside the City Limits of Worcester

The Blackstone River from the dam of the American Steel & Wire Company flows in a southeasterly direction through the towns of Millbury, Sutton, Grafton, Northbridge, Uxbridge and Blackstone, in Massachusetts, a distance of slightly more than 31 miles.

In this distance the river has a fall of 281 feet, which fall, taken from the toe of the American Steel&Wire dam, has at sometime been controlled by 14 dams, of which three, namely, the Nortex dam in Millbury, the Hecla dam in Uxbridge and the Millville dam in Blackstone, have been completely washed out. Where these dams no longer exist the former pond areas are now exposed and the river has assumed a channel or channels through the silt that had accumulated above the dams. The result of this uncontrolled location of the river through these former pond areas is not only unsightly, but, because of its meandering course and the fact that in each case the river has formed several channels more or less parallel, any increase of flow in the river causes an immediate overflow of the present low banks, and any unusual rise of water results in a wide spread of very shallow water, with the consequent deposits of silt and debris.

Of the remaining eleven dams on the Blackstone River, three, the Saunders cotton dam in Grafton, the Anco Mills dam in Sutton and the Worcester Street R. R. Dam in Millbury are no longer

used and should be removed. All the dams along the river were built many years ago, and during the elapsed time there has been an accumulation above them which has to a large extent filled the basins with silt, allowing only a comparatively small pondage with little or no detention value. The waste gates in these dams are of insufficient capacity to pass any unusual excess of water. These gates if re-designed as to capacity and easily accessible operation could be used to great advantage in the control of the flowage of the river.

A study of the surveys that have been made, and the conclusions drawn from a personal inspection of the river, show conclusively that the entire river channel from its source at the dam of the American Steel & Wire Company to the Massachusetts-Rhode Island line should be re-aligned and brought to as uniform a gradient as possible. Those dams which are no longer used as a source of water power should be removed and the channel above and below them brought to a uniform grade and line. At several points accurate measurements have been made of the volume of flood flow. From these calculations the channel area can be determined and made sufficiently large to pass a flood volume without overflowing any surrounding land.

Sketch plans covering the above proposals have been filed with the Massachusetts State Planning Board.

APPENDIX G

POTENTIAL WATER POWER RECOMMENDATIONS FROM W.P.A. REHABILITATION REPORT

The following is from a Works Progress Administration Rehabilitation Report, prepared November 30, 1935, and is quoted direct:

Water Power

Potential Power

Nortex Manufacturing Co., Millbury, Blackstone River:

Propose to combine two falls on the Blackstone River. New Dam, Penstock, Power House and Equipment.

Propose to use dam-site of old Atlanta Woolen Company for the site of a new 15-foot Spillway Section Dam, 58 feet long, which would raise the Water Level 8 feet. A Penstock 550 feet long would run from this point to a new Power House which is to be built on the site of the existing wood frame building of the Nortex Company. This procedure combines two falls on the Blackstone River within 600 feet of each other, making a total head of 25 feet. The Pondage will have very little value as far as draw down is concerned,and will make this development a "run of the river" type.

There is available a head of 25 feet and mean flow of 80 cubic feet per second. Under these conditions, 200 Horse Power could be developed to be converted into electric power. The low water flow is frequently less than 10 cubic feet per second, and this amount is so small that the plant would probably be shut down for considerable time during the low water periods. A capacity development up to the mean flow seems justified.

Standard Weaving Co., Grafton, Blackstone River:

Propose to repair Canal, Tailrace, and rebuild Power House; new equipment. Dam is in place.

The mill is owned by the Whitin Mfg. Co. Formerly, there were three (3) Water Wheels which gave power to the mill. These wheels were supplied by a large canal. One of the wheels, evidently a stand-by unit, was located in a shed on the outside of the building. All three (3) wheels are in very poor condition. Both the

canal and the tailrace will have to be excavated, if they are to be used. The pond made by the 120-foot dam has an area of about ten (10) acres at high water, and will have to be dredged in front of the head gates. A head of 12 feet is available with a uniform flow of about 96 cubic feet per second. These conditions permit a development of about 120 Horse Power. This power could be used in the mill itself, which is in fairly good condition.

Old Rice Mill, Millbury, Singletary Brook:

Proposed to construct a new Penstock, Power House repair Tailrace, and provide new equipment. Dam is in place.

The buildings are no longer standing. All that remains of the Mill are the foundations, part of the brick walls, the chimney, and the remains of the hydraulic equipment. The dam at this location is in good condition. It forms a one (1) acre pond, which is supplied by a brook from Lake Singletary in Sutton, making this a "run of the river" plant.

The power site has available a head of 19 feet. The estimated uniform flow is about 5.4 cubic feet per second. Under these conditions less than 10 Horse Power could be developed and converted into electric power. It can be seen that this power site is uneconomical, and should no longer be considered as a possible means of developed cheap power.

Marie Schuster Mill, East Douglas, Mumford River:

Propose to repair tunnel, construct power house, and provide for new equipment. Dam is in place.

The buildings have fallen down, with only the walls remaining. The dam at this site is located immediately below the Hayward Woolen Co. The dam is an earth dam strengthened by a cut stone wall. The spillway section is made of wood. The pond formed by this dam has an area of about two (2) acres.

There is available a 10-foot head, with an estimated uniform flow of about 40 cubic feet per second. Under these conditions about 40 Horse Power could be developed and converted into electric power. The water for the old wheel was brought from the dam by an underground canal, which is in poor condition.

Worcester Consolidated Street Railway Company, Millbury, Blackstone River:

Report on the use to which the water is put in this steam power plant and the possibility of installing a hydro-electric unit. Dam and canal are in good condition.

This is a steam plant which is capable of generating 5000 KW.

At present, this plant, which is used for stand-by power only, has all electric power supplied by the New England Power Company.

There is a dam in place on the Blackstone River and a canal that runs to this power plant.

Years ago there was a water wheel installation in this plant which ran a generator of about 200 KW capacity. The electricity thus generated was used to light the plant, and for small power units connected with the plant. However, this wheel was removed in 1914, due to a lack of water for both the wheel and the steam condensers.

When this plant is generated at present for stand-by power the water from the Blackstone River is used as cooling water for the surface condensers. There are two (2) large condensers used in this plant and when it is operating at full capacity there is not enough water to successfully run the condensers. It is evident that a water wheel installation at this plant is entirely out of the question.

It is possible that a small hydro-electric unit could be installed to be operated when the plant is not used for stand-by power. This power could be used, as formerly, to light the power plant and run small motors, etc.

There is a head of 13.5 feet and a mean uniform flow of 85.5 cubic feet per second available. These conditions would develop 100 Horse Power to be converted into electric power. However, such an installation would not be economical because the Worcester Consolidated Street Railway Company pays a very small commercial rate for power bought from the New England Power Company.

Lawrence Felting Company, Millville, Blackstone River:

Propose to construct new Dams, repair Canals and gates, rebuild Power Houses and provide for new Hydro-electric equipment.

The plant is now idle and owned by the United States Rubber Company. The buildings, which are located on both banks of the river, are of brick, with wooden floors and columns, and are in fair condition.

In the Spring of 1935 the Lawrence Felting Company, Millville, was ordered to remove their old Wooden Dams by the County Commissioner. One of their two (2) dams was torn out, releasing the pressure on the other. Part of the latter was removed later. This action was requested because the dams were leaking badly, and timbers were rotted beyond repair.

It is proposed in this report to construct two (2) new Concrete Spillway Dams to be located on the approximate sites of the old wooden dams. The crest of the spillway is to be raised two feet, making a head of 13 feet available. The present power canals are in fair condition and can be made serviceable with repairs. The substructures of the existing power houses are to be retained, but new super-structures will be necessary with the new hydro-electric equipment.

Two (2) dams are required at this location because an island divided the Blackstone River into two channels. In this report the channels will be designated as the North and South Channels. There are two (2) power canals which will be named in a like manner.

In the South Channel it is proposed to construct a concrete dam with a spillway length of 115 feet, approximately 7,000,000 cubic feet. This pondage will furnish about an 8 hour supply to the tow wheels.

In order to make the power canals serviceable it is necessary to repair the supply gates and trash racks in both the North and South Canals. The South Canal is filled in with silt and will have to be excavated and cleaned. The North Canal requires draining only.

There is available a head of 13 feet and a mean flow of 295 cubic feet per second. Under these conditions 410 Horse Power could be developed and converted into electric power. During the low water period one of the hydro-electric units would probably be shut down

from one (1) to three (3) months of the year. However, the other unit would be able to operate at fair efficiency with a minimun flow of 65 cubic feet per second. A capacity development up to mean flow seems justified.

Manchaug Mill, Sutton, Mumford River:

Purpose to repair canal and supply gates, construct a new Penstock, Power House, and provide for a new Hydro-electric equipment. Dam is in place.

The plant has been abandoned for some time, and is now owned by the Town of Sutton (Tax Title). The buildings are of the cut granite mill type, and are in a very bad state of repair.

It is proposed to combine two (2) falls on the Mumford River by constructing a new reinforced concrete Penstock from the Power Canal or Lower Tucker Pond to the old Power House of the Manchaug Mill. This procedure would make a head of fifty (50) feet available.

The earth dam at Lower Tucker Pond is in good condition, and will require no repairs. The entrance to the Power Canal is at present filled in with granite blocks and earth fill. This will have to be removed and new Supply Gates installed.

The Power Canal will have to be cleaned and the walls repaired. New head works, Supply Gates and Trash Racks, will have to be constructed at the entrance of the proposed Penstock.

There is available a head of fifty-one (51) feet, more or less, and a mean flow of 71 cubic feet per second, for a twelve (12) hour period, six (6) days per week. Half of this is obtained from storage facilities at this location. Under these conditions 330 Horse Power could be developed and converted into electric power. The above flow could be realized the year round, using storage and a capacity development up to this point seems justified.

Estimates of anything mentioned in this report could only be derived by further field surveys.

APPENDIX H

BLACKSTONE DRAINAGE BASIN

GAZETTEER OF STREAMS

A complete list of streams, lakes and ponds was published by the United States Geological Survey (1916) in Water Supply Paper 415.

The Massachusetts State Planning Board, recognizing the value of a complete "Gazetteer", has, with the co-operation of the Works Progress Administration State Planning Projects, attempted to revise this Gazetteer by adding such data as could be found on the latest U.S.G.S. quadrangle sheets and other available maps. The following is a direct quotation from the above-mentioned publication:

> "As the descriptions are based chiefly on the maps, they vary in accuracy as the maps vary. Each stream is described as rising near the point at which the head of the upper tributary apparently draining the largest area is shown on the map, and the elevation of that point is given as the elevation of the source. It is, of course, recognized that this method does not give results of great precision, but properly causes no greater errors in the determination of length and fall than would be caused by extending each stream to the head of the divide between its basin and that of the adjoining streams. It should be understood, however, that all statements of elevation, length and fall are merely approximate."

We would greatly appreciate your co-operation in calling our attention to any errors or omissions, which will be acknowledged and noted in subsequent publications.

GAZETTEER OF STREAMS

in the

BLACKSTONE BASIN

*AUBURN TEXTILE POND - Worcester County; Town of Auburn; inlets, Kettle and Dark Brooks; outlet, Kettle Brook into Leesville Pond, thence into Blackstone River. Webster sheet.

BAD LUCK POND - (Laurel Lake) Worcester County;Town of Douglas; west of East Douglas; an expansion of Mumford River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

BAD LUCK POND - Worcester County; Town of Douglas; 2 miles west of the village of Douglas and one-half mile north of Wadkin Hill; outlet, a stream about a mile long, flowing northward into Willis Pond Reservoir (outlet to Mumford River and thus through Blackstone River to Seekonk and Providence Rivers and Narragansett Bay). Webster sheet.

*BARKER BROOK - Worcester County;Town of Holden; a stream rising in the Town of Holden; flowing 1½ miles southeast,and south; thence 2 miles south, into the northern arm of North Pond in the City of Worcester (tributary to Blackstone and Seekonk Rivers, thence through Providence River to Narragansett Bay). Worcester sheet, and Special sheet #95-352 E. R. A. State Planning Projects.

BEAVER BROOK - Worcester County;rises on the southwest slope of Winter Hill; flows east of south 4 miles, thence southwestward into one of the reservoirs above Curtis Pond (outlet, Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay). Worcester sheet.

BLACK POND - Worcester County; a very small pond 4 miles southeast of East Douglas. Blackstone sheet.

BLACKSTONE RIVER - Worcester County,Mass.,and Providence County, R.I.; formed near the city of Worcester by the union of several brooks. Kettle Brook, which drains the larger area, and is therefore considered the continuation of the river, rises on the west slope of Little Asneburnskit Hill and flows southeastward to Stoneville, thence eastward and northward to its junction with Blackstone River in the southwestern part of the city of Worcester; from its junction the Blackstone flows southeastward to Seekonk River and thus through Providence River to Narragansett Bay; length to

*Shown but unnamed on U. S. G. S. Sheets.

head of Kettle Brook, about 45 miles; the principal tributaries in Massachusetts below Kettle Brook are Singletary Brook and Quinsigamond, Mumford, West and Mill Rivers. The basin contains no large lakes except Lake Quinsigamond, but small ponds and reservoirs used for storage are numerous; its flow is thus fairly constant and its water powers are very fully utilized; average rainfall on the basin about 45 inches. Gaging stations: Blackstone River at Woonsocket, R.I. 1929 to date; Blackstone River at Worcester, Mass., 1923 to date. Worcester, Marlboro, Webster and Blackstone sheets.

BRANCH RIVER - Worcester County, Mass., and Providence County, R.I.; rises in Wallum Pond near the western boundary of Rhode Island, flows easterly and northeasterly through several small ponds and enters Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay) near Blackstone, Mass.; receives drainage from other ponds and swamps. Webster, Blackstone, and Burrillville sheets.

BROAD MEADOW BROOK - Worcester County. See Dorothy Brook.

*BULLARD ROAD BROOK - Worcester County; Town of Douglas; a stream rising in Northern part of Douglas; near the Oxford town line; flowing 1 mile easterly into Manchaug Pond, (tributary to Blackstone River, and Seekonk Rivers, through Providence River to Narragansett Bay). Blackstone and Webster sheets, and Special Sheet #95-78 E. R. A. State Planning Projects.

BUMMET BROOK - Worcester County; Town of Shrewsbury; rises just south of the village of Shrewsbury; flows southward to North Grafton, where it enters Quinsigamond River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay); length, 5 miles. Marlboro and Blackstone sheets.

*BURT BROOK - Worcester County; Town of Sutton; a stream rising in the southeastern part of Town of Sutton; flows 2 miles easterly, into Whitins Pond, in Town of Northbridge; thence 5 miles southeasterly to Blackstone River (tributary to Seekonk River through Providence River to Narragansett Bay). Blackstone and Webster sheets and Special sheet #95-219 E. R. A. State Planning Projects.

BURT POND - also called SWAIN'S POND - Worcester County; Town of Sutton; inlet and outlet, Purgatory Brook, which flows through the pond to Whitins Pond on Mumford River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

*CAMP GROUND BROOK - Worcester County; Town of Uxbridge; a stream rising on east slope of Wadkin Hill, flowing 1½ miles northeasterly, to Bad Luck Pond (tributary to Mumford River, through Blackstone

*Shown but unnamed on U. S. G. S. Sheets.

and Seekonk Rivers thence through Providence River to Narragansett Bay). Blackstone sheet, and Special sheet #95-78 E. R. A. State Planning Projects.

CARPENTERS POND -(Sutton) Worcester County;Town of Northbridge; outlet into Whitins Pond into Mumford River thence into Blackstone River. Blackstone sheet.

*CARROLL BROOK - Worcester County;Town of Grafton; a stream rising in Northern section Town of Grafton; flowing, 1½ miles southwesterly, into Goddard Pond, thence to Quinsigamond River to Blackstone River (tributary to Seekonk River; thence through Providence River to Narragansett Bay). Blackstone sheet and Special sheet #95-112 E. R. A. State Planning Projects.

*CARTERS BROOK - Worcester County; Town of Millbury; a stream rising on northern slope of Mt. Ararat, at Old Common; flowing 1 mile north and northeasterly to Blackstone River (tributary through Seekonk and Providence Rivers to Narragansett Bay), at Millbury. Webster sheet, and Special sheet #95-189 E. R. A. State Planning Projects.

*CEDAR BROOK - Worcester County;Town of Douglas; a stream rising in east slope of Wood Hill; flowing 2 miles northeasterly, into Willis Pond, about 1⅓ miles to Willis Reservoir; 2 miles northeast to Mumford River, 2 miles southeasterly, 3 miles northeasterly into Whitin Pond, 7 miles southeasterly to Blackstone River (tributary to Seekonk River, thence through Providence River to Narragansett Bay). Blackstone sheet, and Special sheet #95-78 E. R. A. State Planning Projects.

CENTER BROOK - Worcester County; Town of Upton; rises a mile north of Pratt Pond;flows southward 4⅓ miles into West River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

*CENTERVILLE BROOK - Worcester County; Town of Grafton; a stream rising in northwest slope of Brigham Hill; flowing 1 mile easterly joins Quinsigamond River, about 12 miles southeasterly to Blackstone River (tributary to Seekonk River, thence through Providence River to Narraganset Bay). Blackstone sheet.

CHOCKALOG POND - Worcester County; a very small pond 4 miles southeast of East Douglas. Blackstone sheet.

CLARK RESERVOIR - Worcester County;⅓ mile east of Sutton;inlet, head of Cold Spring Brook; outlet, Cold Spring Brook to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay). Webster and Blackstone sheets.

*Shown but unnamed on U.S.G.S. Sheets.

*COAL MINE BROOK - Worcester County; City of Worcester; a stream rising on northeast slope of Green Hill, flowing about 1 mile easterly of the northern arm of Lake Quinsigamond, (tributary to Quinsigamond River thence through Blackstone and Seekonk River, through Providence River to Narragansett Bay). Worcester sheet, and Special sheet #95-352 E. R. A. State Planning Projects.

COES RESERVOIR -(Worcester) Worcester County;City of Worcester, south of Patches Pond; outlet, Tatnuck Brook into Blackstone River. Worcester sheet.

COLD SPRING BROOK - Worcester County; rises 1 mile southwest of the village of Sutton; flows northeastward through Clark Reservoir and Pleasantdale Pond into Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay), near Wilkinsonville; length, about 4 miles. Webster and Blackstone sheets.

*COOK ALLEN BROOK - Worcester County; Town of Sutton; a stream rising in the east; flowing about 2 miles easterly to Whitins Pond; Town of Northbridge; (tributary to Blackstone River through Seekonk River, thence through Providence River to Narragansett Bay). Blackstone sheet.

COOKS POND - Worcester County; City of Worcester, south of Holden Reservoir No. 2; outlet, Tatnuck Brook into Patches Pond thence into Blackstone River. Worcester sheet.

*COOPER TOWN BROOK - Worcester County; Town of Douglas; a stream rising in northern section of Douglas; flowing about 2 miles southeasterly, into western arm of the Willis Pond Reservoir, 2 miles northeasterly to the Mumford River (tributary through Blackstone and Seekonk Rivers; thence through Providence River to Narragansett Bay). Webster sheet and Special sheet #95-352 E. R. A. State Planing Projects.

*CRONIN BROOK - Worcester County; Town of Grafton; a stream rising southern slope of Brigham Hill; flowing 2 miles southeasterly about 1 mile above Fisherville; to the Blackstone River; (tributary through Seekonk River; thence through Providence River to Narragansett Bay). Blackstone sheet; and Special sheet #95-112 E. R. A. State Planning Projects.

CURTIS POND - Worcester County;City of Worcester;principal inflowing streams, Kettle Brook and Tatnuck Brook; outlet,(Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay). Webster sheet.

DARK BROOK - Worcester County; Town of Auburn; rises 1mile

*Shown but unnamed on U. S. G. S. Sheets.

northeast of Rochdale; flows southeastward 1½ miles, thence northeastward through Stoneville Reservoir to Kettle Brook (tributary through Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay), near Stoneville; length, about 5 miles. Webster sheet.

*DEVLIN BROOK - Worcester County;Town of Sutton; a stream rising in village of South Sutton; flowing about 1½ miles southeasterly, into Prentice Brook, 1 mile northeasterly to Whitins Pond, 5 miles southeasterly to Blackstone River; (tributary to the Seekonk River; thence through Providence River to Narragansett Bay). Blackstone sheet, and Special sheet #95-219, E. R. A. State Planning Projects.

DOROTHY BROOK - Worcester County; rises on the south slope of Oak Hill, in the City of Worcester; flows southeastward to Dorothy Pond, thence southwestward into Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay) at Millbury; called Broad Meadow Brook above Dorothy Pond; length to head of Broad Meadow Brook, 5 miles. Worcester, Webster and Blackstone sheets.

DOROTHY POND - Worcester County; at south base of Dorothy Hill; inlet, Broad Meadow Brook (head of Dorothy Brook); outlet, Dorothy Brook to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay). Webster and Blackstone sheets.

*DUNLEAVY BROOK - Worcester County; Town of Douglas; a stream rising in northeastern section of Douglas; flowing about 2 miles northward; through Uxbridge into southern arm of Whitins Pond about 2 miles northeasterly to Whitinsville,5 miles southeasterly through Mumford River to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay). Blackstone sheet, and Special sheet #95-308 E. R. A. State Planning Projects.

DUNNS POND - Worcester County; Town of Auburn; 1 mile north of the village of Auburn; inlet and outlet, Ramshorn Brook (tributary to Kettle Brook and thus through Blackstone River to Seekonk and Providence Rivers and Narragansett Bay). Webster sheet.

EDDY POND - Worcester County; Town of Auburn; outlet,Ramshorn Brook and Kettle Brook, thence into Blackstone River. Webster sheet.

EMERSON BROOK - Worcester County; Town of Douglas;rises 2 miles southeast of East Douglas; flows southeastward 2 miles, northeastward 2 miles, then eastward and southeastward again 2 miles to its junction with Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay). Blackstone sheet.

*Shown but unnamed on U. S. G. S. Sheets.

FISHERVILLE POND - Worcester County; Town of Grafton; outlet Blackstone River. Blackstone sheet.

FLINTS POND - Worcester County; west of North Grafton; an expansion of Quinsigamond River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay); just below the outlet of Lake Quinsigamond. Blackstone sheets.

FOX BROOK - Worcester County;Town of Blackstone; rises 1½ miles northwest of Waterbug Hill; flows southeastward 3 miles, then somewhat east of south 2 miles to its junction with Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay) near the City of Blackstone. Blackstone sheet.

GODDARD POND - Worcester County;Town of Grafton; inlet and outlet, Quinsigamond River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

*GRASS HILL BROOK - Worcester County;Town of Millbury; a stream rising on eastern slope of Grass Hill; flowing 1 mile southeasterly, into Ramshorn Brook; at West Millbury, 5 miles northwesterly to City of Worcester, where it meets Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay). Webster sheet, and Millbury sheet of Conservation maps and Special sheet #95-189 E. R. A. State Planning Projects.

GREAT BROOK - Worcester County; rises 1½ miles northeast of Summit Station; flows in general southeastward into Lake Quinsigamond (outlet, Quinsigamond River to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay); length, about 4 miles. Worcester sheet.

HARRIS POND - Worcester County;Town of Blackstone; an expansion of Mill River (tributary to Blackstone River, and thus through Seekonk and Providence Rivers to Narragansett Bay), north of the City of Woonsocket, R. I. Blackstone sheet.

HECLA POND - Worcester County; Town of Uxbridge, south of Rice City Pond; outlet, Blackstone River. Blackstone sheet.

HOLDEN RESERVOIR - No. 1. - Worcester County; between Stone House Hill and Asnebumskit Hill; three small inflowing streams; natural outlet, Tatnuck Brook to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay); used as a part of the water-supply system of Worcester. Worcester sheet.

*Shown but unnamed on U. S. G. S. Sheets.

HOLDEN RESERVOIR - No. 2. - Worcester County; Town of Holden; below Holden Reservoir No. 1; outlet, Tatnuck Brook into Blackstone River. Part of the City of Worcester Water Supply System, Worcester sheet.

HOP BROOK - Worcester County;rises a mile east of Wigwam Hill; flows southeastward into Mill River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay) near East Blackstone; about 4 miles long. Blackstone sheet.

HOVEY POND - Worcester County; Town of Grafton, part of Lake Quinsigamond; outlet, Quinsigamond River into Hoddard Pond thence into Blackstone River. Blackstone sheet.

IRONSTONE RESERVOIR - Worcester County, Mass., and Providence County, R. I., one inflowing stream; outlet a stream $\frac{1}{2}$ mile long flowing northeastward into Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay); the reservoir is about 2 miles long and 1/8 mile in maximum width. Blackstone sheet.

JENKS RESERVOIR - Worcester County; Town of Bellingham; outlet, Peters River into Mill River; thence into Blackston River. Franklin sheet.

JORDAN POND - Worcester County; Town of Shrewsbury; a small pond $\frac{1}{4}$ mile east of Lake Quinsigamond (tributary through Quinsigamond River to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay) into which it discharges by a westward flowing stream. Marlboro sheet.

JOURDANS POND - (Wildwood Lake) - Worcester County; Town of Upton; outlet, West River into Blackstone River. Blackstone sheet.

*KELLY BROOK - Worcester County; City of Worcester; a stream rising in northern section of City of Worcester; at Summit Station; flowing 1 mile southeasterly into Great Brook, 2 miles southeasterly through northern arm of Lake Quinsigamond, to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay). Worcester sheet and Special sheet #95-352 E. R. A. State Planning Projects.

KETTLE BROOK - Worcester County; rises on the west slope of Little Asnebumskit Hill; flows southeastward through many small ponds to Stoneville; thence eastward and northward to its junction with Blackstone River (tributary through Seekonk and Providence Rivers to Narragansett Bay) in the southwestern part of the city of Worcester; principal tributaries, Lynde, Dark, and Ramshorn Brooks. Worcester and Webster sheets.

*Shown but unnamed on U. S. G. S. Sheets.

KETTLE BROOK RESERVOIRS No. 1, 2, 3, and 4 - Worcester County; southern part of Paxton and northeastern part of Leicester; outlet, Kettle Brook into Waite Pond, thence into Blackstone River; part of the City of Worcester Water Supply system. Worcester sheet.

*LAKE VIEW BROOK - Worcester County; City of Worcester; a stream rising on east slope of Oak Hill; flowing about 1½ miles northeasterly to Lake Quinsigamond, 6 miles southeasterly through City of Worcester, to Blackstone River (tributary through Seekonk and Providence Rivers to Narragansett Bay). Worcester sheet and Special sheet #95-352 E. R. A. State Planning Projects.

LAUREL LAKE - Douglas - See Bad Luck Pond.

LEESVILLE POND - Worcester County; Town of Auburn; inlets, Kettle and Ramshorn Brook; Outlet, Kettle Brook into Blackstone River. Webster sheet.

LITTLE POND - Worcester County; Town of Mendon; and expansion of Meadow Brook, which flows through it to West River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

LYNDE BROOK - Worcester County; rises on the southwest slope of Asnebumskit Hill; flows southeastward and joins Kettle Brook (tributary through Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay) in the pond at Cherry Valley; passes through Lynde Brook Reservoir. Worcester and Webster sheets.

LYNDE BROOK RESERVOIR - Worcester County; north of Cherry Valley; inlet and outlet, Lynde Brook (tributary through Kettle Brook to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Worcester sheet.

MANCHAUG POND - Worcester County; northwest of the village of Manchaug; inlet and outlet, Mumford River (tributary to Blackstone River, and thus through Seekonk and Providence Rivers to Narragansett Bay); nearly 2 miles long; ½ mile wide. Webster sheet.

MEADOW BROOK - Worcester County; rises in Nipmuck Pond a mile southwest of the village of Mendon; flows southwestward 2 miles, than westward about a mile into West River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay); tributary, Wigwam Brook. Blackstone sheet.

MILL BROOK - Worcester County; rises 1 mile northwest of Summit Station; flows southeastward about a mile, thence southward through the City of Worcester to Blackstone River (tributary through Seekonk River to Providence River, and thus to Narragansett Bay); principal tributary, stream from North Pond passes through several small ponds. Worcester sheet.

*Shown but unnamed on U.S.G.S. Sheets.

MILL RIVER - Middlesex and Worcester Counties; rises about 2 miles south of Woolville in the town of Hopkinton; flows in general somewhat east of south to its junction with Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay) at Woonsocket, R. I.; length, 16 miles;principal tributaries, Muddy, Round Meadow, and Hop Brooks; passes through several ponds. Blackstone sheet.

MISCOE BROOK - Worcester County; Town of Grafton; the head of West River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

*MOFFETT BROOK - Worcester County; Town of Northbridge; a stream rising at Northbridge Center; flowing 1 mile southerly; into Northbridge Brook; 2 miles southerly to Whitins Pond, 2 miles southeasterly to Mumford River, 5 miles southeasterly to Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay). Blackstone sheet, and Special sheet #95-219 E. R. A. State Planning Projects.

*MOLLY BROOK - Worcester County; Town of Uxbridge; a stream rising in southern section of Uxbridge; flowing 2 miles southeasterly into Ironstone Reservoir; 1 mile northerly to Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay) at Ironstone Village. Blackstone sheet; Conservation Maps; and Special sheet #95-308 E. R. A. State Planning Projects.

MUDDY BROOK - Worcester County;rises 1¼ miles west of Hopedale; flows southeastward 4 miles, thence very irregularly eastward into Mill River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

MUMFORD RIVER - Worcester County;rises in a pond at West Sutton; flows southeastward to Manchaug Pond,thence eastward and southeastward to Bad Luck Pond at East Douglas, northeastward and northward to Whitins Pond, thence southeastward to its junction with Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay) near Uxbridge; length, about 15 miles. Webster and Blackstone sheets.

NEWTON POND - Worcester County;on Quinsigamond River (tributary through Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay) northwest of Harlow Hill. Marlboro sheet.

NIPMUCK POND - Worcester County; 1 mile southwest of the village of Mendon; outlet, Meadow Brook to West River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

*Shown but unnamed on U.S.G.S. Sheets.

NORTH POND - (Indian Lake)- Worcester County; north of the City of Worcester; outlet, a stream 1/8 mile long, flowing eastward into Mill Brook (tributary through Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay) north of Northville; nearly a mile long and 1/2 mile wide. Worcester sheet.

NORTH POND - Middlesex and Worcester Counties; inlet and outlet, Mill River, which flows through it to Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay); more than 2 miles long; about 1/4 wide. Blackstone sheet.

*NORTHBRIDGE BROOK - Worcester County; Town of Northbridge; a stream rising in eastern section of the Town of Sutton; flowing 1 mile southeasterly into Northbridge Center, 2 miles southerly through Northbridge to Whitins Pond, 2 miles easterly to Mumford River, 5 miles southeasterly, to Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay). Blackstone sheet, and Special sheet #95-219 E. R. A. State Planning Projects.

*NORTH POND BROOK - Worcester County; Town of Holden; a stream rising in southeastern section of Town of Holden; flowing 1/2 mile southerly to Worcester City line,1 1/2 miles southeasterly through section between Indian Hill and Winter Hill to north arm of North Pond (Indian Lake) 1/2 mile to Mill Brook (tributary to Seekonk River and thus through Providence River to Narragansett Bay). Worcester sheet, and Special sheet #95-352 E. R. A. State Planning Projects.

PATCHES POND - Worcester County; City of Worcester; outlet,Tatnuck Brook into Coes Reservoir thence into Blackstone River. Worcester sheet.

PETERS RIVER - Worcester County; rises in Town of Bellingham at elevation of 300 feet; joins Mill River which joins Blackstone River in Rhode Island. Franklin sheet.

PLEASANTDALE POND - Worcester County; Town of Sutton; an expansion of Cold Spring Brook (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

POUDVILLE POND - Worcester County; Town of Auburn; inlets,Stone and Ramshorn Brooks; Outlet, Ramshorn Brook into Dunn's Pond into Kettle Brook thence into Blackstone River. Webster sheet.

*Shown but unnamed on U.S.G.S. Sheets.

*POOR FARM BROOK - Worcester County; City of Worcester; a stream rising on north side of Green Hill; flowing 1 mile easterly into Great Brook, 1/2 mile easterly to northern arm of Lake Quinsigamond; 6 miles southerly through Lake Quinsigamond to Blackstone River (tributary Seekonk River and thus through Providence River to Narragansett Bay). Worcester sheet, and Special sheet #95-352 E.R.A. State Planning Projects.

POUT POND - Worcester County;Town of Boylston; outlet into Lake Quinsigamond, thence into Quinsigamond River to Blackstone River. Marlboro sheet.

PRATT POND - Worcester County; Town of Upton; near head of Center Brook, which flows through it to West River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

*PRENTICE BROOK - Worcester County; Town of Sutton;a stream rising in South Sutton Hill;flowing 1 mile eastward;1 1/2 miles northeasterly to Whitins Pond,1 1/2 miles easterly through Whitinsville, where it meets Mumford River, 5 miles southeasterly to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay). Blackstone sheet, and Special sheet #95-219 E.R.A. State Planning Projects.

PURGATORY BROOK - Worcester County;Town of Sutton; rises a mile west of Purgatory Chasm; flows southeastward and eastward to Burts Pond; thence southward to Whitins Pond on Mumford River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay); length, 3 miles. Blackstone sheet.

QUINSIGAMOND LAKE - Worcester; an expansion of Quinsigamond River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay);about 5 1/2 miles long, 1/8 to 1/4 mile wide in the upper part and one about 1 mile wide in the lower part; altitude, 360 feet above sea level. Worcester, Marlboro and Blackstone sheets.

QUINSIGAMOND RIVER - Worcester County;rises about 1 mile southeast of Boylston Center in the Town of Boylston; flows southwestward to Sewell Pond, thence southward through Newton Pond to the head of Lake Quinsigamond, from which it flows southeastward to Goddard Pond, thence southward to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay) at Fisherville; length, 14 miles; principal tributaries, Great and South Jordan Brooks, which flow into Lake Quinsigamond. Worcester, Marlboro and Blackstone sheets.

*Shown but unnamed on U.S.G.S Sheets.

RAMSHORN BROOK - Worcester County; rises 1 mile south of Ramshorn Pond; flows northeastward through the pond to West Millbury, thence northwestward to Stoneville, where it enters the pond on Kettle Brook (tributary to Blackstone River, and thus through Seekonk and Providence Rivers to Narragansett Bay); length, 7 miles, Webster sheet.

RAMSHORN POND - Worcester County;1 mile south of West Millbury; outlet, Ramshorn Brook to Kettle Brook (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Webster sheet.

RICE CITY POND - Worcester County; Town of Uxbridge; outlet, Blackstone River above junctions of West and Mumford Rivers with Blackstone River. Blackstone sheet.

ROCK MEADOW BROOK - Worcester County; rises on the south slope of Miscoe Hill; flows southwestward 3 1/2 miles into West River (tributary to Blackstone River, and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

*ROUND MEADOW BROOK - Worcester County; Town of Mendon; a stream rising on eastern slope of Inman Hill;flowing 1 1/2 miles southeasterly into Mill River 5 miles southerly through Town of Blackstone, to Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay) at Woonsocket. Blackstone sheet, and Special sheet #95-182 E. R. A. State Planning Projects.

SALISBURY POND - Worcester County; City of Worcester; inlet, Mill Brook; outlet, Mill Brook Channel into Blackstone River. Worcester sheet.

*SCADDER BROOK - Worcester County;Town of Uxbridge;a stream rising on northern slope of Bald Hill; in East Douglas; flowing 1 1/2 miles southeasterly; 1 mile easterly, 1 mile northeasterly to Emerson Brook;2 1/2 miles southeasterly to Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay). Blackstone sheet, and Special sheet #95-308 E. R. A. State Planning Projects

SEWELL POND - Worcester County; Town of Boylston; a small pond near the head of Quinsigamond River (tributary through Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay), which flows through it to Newton Pond. Marlboro sheet.

SIBLEY RESERVOIR - Worcester County;1 mile north of the village of Sutton; outlet, a stream flowing eastward into Cold Spring Brook (tributary through Blackstone River to Seekonk River and thus through Providence River to Narragansett Bay). Webster sheet.

*Shown but unnamed on U.S.G.S. Sheet.

SILVER LAKE - Worcester County; Town of Grafton; inlet, Miscoe Brook (head of West River); outlet, West River to Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay). Blackstone sheet.

SINGLETARY BROOK - Worcester County; rises 1 mile north of West Sutton; flows northeastward through Singletary Pond into Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay) at Millbury; about 5 miles long. Webster sheet.

SINGLETARY POND - Worcester County; a mile northwest of Sutton; inlet and outlet, Singletary Brook (tributary to Blackstone River and thus through Seekonk River to Providence River and Narragansett Bay); 1 1/2 miles long; 1/2 mile wide. Webster sheet.

SOUTH MEADOW BROOK - Worcester County;Town of Shrewsbury; rises northwest of the village of South Shrewsbury; flows southwestward and southward into Lake Quinsigamond (outlet, Quinsigamond River to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay); length, 2 1/2 miles. Marlboro sheet.

SPRING BROOK - Worcester County; Town of Mendon; rises a mile south of the village of Mendon, flows southward one mile, and eastward 1 1/2 miles into Muddy Brook (tributary through Mill River to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Blackstone sheet.

SPRUCE POND - Worcester County; Town of Boylston; outlet, into Lake Quinsigamond, thence into Quinsigamond River to Blackstone River. Marlboro sheet.

*STATE HOSPITAL BROOK - Worcester County; City of Worcester; a stream rising on east slope of Millstone Hill; flowing 1 mile easterly through Massachusetts State Hospital grounds, 1 mile easterly to Lake Quinsigamond, 6 miles through to Blackstone River (tributary through Seekonk and Providence Rivers to Narragansett Bay). Worcester sheet, and Special sheet #95-352 E. R. A. State Planning Projects.

STEVENS POND - Worcester County;Town of Sutton;east of Manchaug Pond; outlet, Mumford River into Whitins Pond thence into Blackstone River. Webster sheet.

STONE BROOK - Worcester County; Town of Millbury; rises on the southwest slope of Grass Hill; flows northeastward into Ramshorn Brook (tributary through Kettle Brook to Blackstone River; and thus through Seekonk and Providence Rivers to Narragansett Bay) near Pondville; length, about 2 miles. Webster sheet.

*Shown but unnamed on U.S.G.S. Sheets.

STONEVILLE RESERVOIR - Worcester County; Town of Auburn; 1 mile southwest of Stoneville; inlet, Dark Brook; outlet, Dark Brook to Kettle Brook (tributary to Blackstone River, and thus through Seekonk and Providence Rivers to Narragansett Bay). Webster sheet.

SWANS POND - also called Burt Pond - Worcester County; Town of Sutton; outlet into Whitins Pond to Mumford River, thence into Blackstone River. Blackstone sheet.

TATNUCK BROOK - Worcester County; rises north of Stone House Hill; flows westward about a mile, thence southeastward through a series of artificial reservoirs to Curtis Pond, at the head of Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay); length, 7 miles. Worcester and Webster sheets.

TATNUCK BROOK RESERVOIRS, No. 1 & 2 - See Holden Reservoirs.

UPPER RESERVOIR - Worcester County; Town of Paxton; on west slope of Little Asnebumskit Hill; natural outlet, Kettle Brook to Blackstone River, and thus through Seekonk and Providence Rivers to Narragansett Bay; used as a part of the water supply systems of Worcester. Worcester sheet.

*UXBRIDGE ROAD BROOK - Worcester County; Town of Douglas; a stream rising on northern slope of Bald Hill; 2 miles northerly to Mumford River; 4 miles southeasterly to Blackstone River (tributary through Seekonk River and thus through Providence River to Narragansett Bay). Blackstone sheet, and Special sheet #95-78 E. R. A. State Planning Projects.

WAITE POND - Worcester County;Town of Leicester; outlet, Kettle Brook into Blackstone River. Worcester sheet.

WALLUM POND - Worcester County, Massachusetts, and Providence County, R. I., outlet, Branch River to Blackstone River (tributary to Seekonk River and thus through Providence River to Narragansett Bay); about 2 miles long and 1/4 mile wide. Webster sheet.

WARREN BROOK - Worcester County; rises 3 miles north of Upton; flows west of south 4 miles into West River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay) at West Upton. Blackstone sheet.

WEST RIVER - Worcester County; rises 2 miles northeast of Grafton; flows southward to Silver Lake, southeastward to the north base of West Hill, thence southwestward into Blackstone River (tributary through Seekonk River to Providence River and thus to Narragansett Bay); length 12 miles; principal tributaries, Warren,

*Shown but unnamed on U.S.G.S. Sheets.

Center, Rock Meadow, and Meadow Brook; called Miscoe Brook above Silver Lake. Blackstone sheet.

WHITINS POND - Worcester County; a large pond on Mumford River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay) west of Whitinsville. In addition to Mumford River the pond receives Purgatory Brook and several small streams. Blackstone sheet.

WIGWAM BROOK - Worcester County; rises in a pond north of Wigwam Hill; flows northwestward into Meadow Brook (tributary through West River to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay); 1 1/2 miles long. Blackstone sheet.

WILLIS POND RESERVOIR - Worcester County; 2 miles south of the village of Manchaug; three inflowing streams, including one from Bad Luck Pond (north of Wadkin Hill); outlet, a stream 2 miles long flowing northeastward into Mumford River (tributary to Blackstone River and thus through Seekonk and Providence Rivers to Narragansett Bay). Webster sheet.

ZACHARY POND - Worcester County; Town of Upton; outlet, Warren Brook to West River, thence into Blackstone River, Blackstone sheet.

NOTE: U.S.G.S. sheets dated 1885 - 1888 - with a partial revision in 1917.